HoGent

BUSINESS AND INFORMATION MANAGEMENT

Professional Bachelor in Applied Computer Science
Academic year 2012-2013

Solving CAPTCHA using neural networks

Submitted on 10 June 2013

Student:
Pieter Van Eeckhout

Mentor:
Johan Van Schoor

HoGent Business & Information Management
Professional Bachelor in Applied Computer Science
Academic year 2012-2013

Solving CAPTCHA using neural networks

Submitted on 10 June 2013

Student:
Pieter Van Eeckhout

Mentor:
Johan Van Schoor

Contents

Abstract

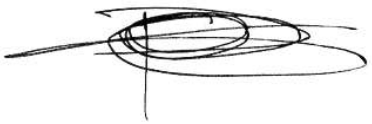
Preamble

Firstly, dear reader, I would like to thank you for taking the time to read this thesis. Without an audience this entire endeavour would not mean as much as it does right now, while you are reading it's results. I personally believe this is because I would like my life not to go unnoticed. So if this thesis helps, or influences you in any way, then this work has gained more meaning.
Secondly I would like to thank the following persons who have made it possible for me to arrive at this point. Special thanks and mentions go to:

- my parents, for supporting me and giving me the opportunity and supplying the means for me to pursue my academic career.
- my girlfriend, because she has helped me countless times, she helped me through the rough spots. Because she never once complained about the time consuming job of writing this work.
- my good friends, willing proof readers and content critics Wouter Dekens, Patrick Van Brussel and Thijs van der Burgt.
- Johan Van Schoor and Bert Van Vreckem for the support, organisation, guidance and feedback.

Bare in mind that this is not an exclusive list. So lastly I would like to thank all the other people who are not mentioned by name, like the teaching and support staff at University College Ghent.

Ghent BELGIUM, June 2013



Pieter Van Eeckhout

Chapter 1

Solving CAPTCHA using neural networks

The target audience. This thesis was written with an audience in mind that already has some technical understanding of computers and how they operate on hardware level (processor etc.). If you feel that your current knowledge is insufficient, or just want to read up some more, then I refer you to the "How Computers Work - Processor and Main Memory" [**?**] e-book.

The history of SPAM. Ever since the internet found its way into our daily lives, there have been people out there who don't always have other people's best interests in mind. I am referring to spammer, people aiming to advertise their product, services, etc . . . in an aggressive manner. The methods of advertising include but are not limited to:

- Sending bulk emails without the recipients permission (SPAM).
- Posting irrelevant links and information on fora and various social media.
- Flooding chat channels with their links and information.

These emails, posts and messages inconvenience the end-users, requiring time to filter out the junk. The economic costs of SPAM has led to a decrease in the Japanese GDP by 500 billion Yen (3.78 billion Euro) in 2004 and were projected to reach a decrease of 1% of the total GDP by 2010 unless adequate countermeasures were taken [**?**]. [**?**] researched the economic arguments for regulating junk mails and the efficiency of these regulations.

Birth of CAPTCHA. The two previously mentioned researches signify the importance and impact of SPAM on our daily lives. The users of the internet

quickly tried to implement methods to prevent spammers from spreading their advertisements to the masses. Several prevention and detection methods and systems were developed successfully. These range from hidden text only visible to automated scripts, to invalid HTML tags. One of the methods developed for this purpose is a CAPTCHA test. CAPTCHA is an acronym based on the word "capture" and stands for 'Completely Automated Public Turing test to tell Computers and Humans Apart'. An attempt to trademark the term was made by Carnegie Mellon University on 15 October 2004, but the application was eventually dropped on 12 April 2008

Spammers fight back. All these prevention and detection methods did not stop the spammers from trying to reach an audience as large as possible. The spammers rely on a large target audience because of the return rates being as low as 0.0023% [**?**]. Trying to reach such a large audience the spammers start to device ways to circumvent or break the existing systems. One of these methods is solving CAPTCHA tests by making use of the adaptive learning and pattern recognizing capabilities of neural networks. These networks can be used to recognize letters from images with adversarial clutter. This is the area I will focus on in this thesis. This thesis will list some of the difficulties regarding the extraction of relevant data from a CAPTCHA, and how to possibly overcome these difficulties. However the main focus will be on searching for the types and configuration of neural networks best used for pattern recognition.

Chapter 2

Premise and research questions

2.1 Premise

The main objective of this thesis is to ascertain whether neural networks are capable of solving the current generation of CAPTCHA images. we will define the premise as following:

"Are neural networks a viable tool for solving the current generation of CAPTCHA?"

2.2 Research questions

The research can be divided into two separate subjects. If one was to develop software for automatic CAPTCHA solving, following questions and problems would need to be addressed.

CAPTCHA:

- What are the different types of CAPTCHA?
- How can the distorted text be extracted?

Neural networks:

- How do neural networks operate?
- Which types of neural networks are well suited pattern recognition?
- What network configuration would perform best?

general:

- How future proof would this solution be?
- Is there enough economic incentive to invest in development?

Chapter 3

Methodology

Research philosophy.

Research approach.

Access.

Research strategy.

Chapter 4

Corpus

4.1 CAPTCHA

4.2 Neural Networks

4.3 Implementation

Chapter 5

Conclusion

Appendix A

Sourcecode

A.1 Package captchabuilder

A.2 Package captchacleanup

A.3 Package neuralnetworks

A.4 Package captchabuilder.builder

Listing A.1: captchabuilder.Captcha

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
```

```
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder;

import java.io.Serializable;
import java.awt.image.BufferedImage;
import java.io.IOException;
import java.io.ObjectInputStream;
import java.io.ObjectOutputStream;
import java.util.Date;
import javax.imageio.ImageIO;

/**
 * Captcha.java (UTF-8)
 *
 * Captcha object, contains the image, the answer, buildstring used to
     create
 * the image and the date the captcha was create.
 *
 * 2013/04/17
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.7
 * @version 1.0.7
 */
public class Captcha implements Serializable {

    private static final long serialVersionUID = 617954136L;
    private String answer;
    private String buildSequence;
    private boolean caseSensative;
    private Date timestamp;
    private BufferedImage captchaImage;

    /**
     * Constructor
     *
     * @param buildSequence
     * @param answer
     * @param caseSensative
     * @param captchaImage
     * @param timestamp
     */
    public Captcha(String buildSequence, String answer, boolean
        caseSensative, BufferedImage captchaImage, Date timestamp) {
        this.buildSequence = buildSequence;
        this.answer = answer;
        this.captchaImage = captchaImage;
        this.timestamp = timestamp;
        this.caseSensative = caseSensative;
    }

    /**
     * Validates if the string passed matches the answer stored
     *
     * @param response the response given by the user
     * @return true or false
```

```
     */
    public boolean isCorrect(String response) {
        if (caseSensative) {
            return answer.equals(response);
        } else {
            return answer.equalsIgnoreCase(response);
        }
    }

    public String getAnswer() {
        return answer;
    }

    public BufferedImage getImage() {
        return captchaImage;
    }

    public Date getTimeStamp() {
        return timestamp;
    }

    public String getBuildSequence() {
        return buildSequence;
    }

    public boolean isCaseSensative() {
        return caseSensative;
    }

    public Date getTimestamp() {
        return timestamp;
    }

    @Override
    public String toString() {
        return new StringBuilder()
                .append("[Answer: ")
                .append(answer)
                .append("][Case sensative: ")
                .append(caseSensative)
                .append("][Timestamp: ")
                .append(timestamp)
                .append("][Image: ")
                .append(captchaImage)
                .append("][Build Sequence: ")
                .append(buildSequence)
                .append("]")
                .toString();
    }

    private void writeObject(ObjectOutputStream out) throws IOException {
        out.writeObject(buildSequence);
        out.writeObject(answer);
        out.writeObject(caseSensative);
        out.writeObject(timestamp);
        ImageIO.write(captchaImage, "png", ImageIO.createImageOutputStream(
            out));
    }

    private void readObject(ObjectInputStream in) throws IOException,
        ClassNotFoundException {
        buildSequence = (String) in.readObject();
```

```
            answer = (String) in.readObject();
            caseSensative = (Boolean) in.readObject();
            timestamp = (Date) in.readObject();
            captchaImage = ImageIO.read(ImageIO.createImageInputStream(in));
        }
}
```

A.5 Package captchabuilder.elementcreator

A.6 Package captchabuilder.util

A.7 Package captchacleanup.image

A.8 Package captchacleanup.textfromimage

A.9 Package neuralnetworks.network

A.10 Package neuralnetworks.util

Listing A.2: captchabuilder.builder.BackgroundParser

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
```

```
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.builder;


import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background.BackgroundProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    producer.BackgroundProducerType;
import java.util.Arrays;
import org.apache.commons.cli.ParseException;

/**
 * BackgroundParser.java (UTF-8)
 *
 * Parses the string arguments for rendering a background
 *
 * 2013/04/17
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.8
 * @version 1.0.13
 */
public class BackgroundParser {

    /**
     * Parses the string arguments for rendering a background, creates a
     * BackgroundProducer and passes it to the CaptchaBuilder
     *
     * @param buildSequenceOptions the string arguments for building a
     * background
     * @param builder the CaptchaBuilder Object to be modified
     * @return a modified CaptchaBuilder object
     * @throws org.apache.commons.cli.ParseException
     * @see CaptchaBuilder
     */
    public static CaptchaBuilder parse(String[] buildSequenceOptions,
        CaptchaBuilder builder) throws ParseException {
        if (buildSequenceOptions.length == 0) {
            //return builder.addBackground();
            builder.addBuildSequence(new BackgroundProducerBuilder(
                BackgroundProducerType.TRANSPARENT));
            return builder;
        }

        if (buildSequenceOptions.length > 1) {
            throw new ParseException("Background takes a max of 1 arguments"
                );
        }

        for (String backgroundOption : buildSequenceOptions) {
            if (!backgroundOption.isEmpty()) {
                try {
                    String[] optionArgs = backgroundOption.split(
                        CaptchaConstants.buildSequencelvl3Delim);
                    BackgroundProducerType backgroundProducerType =
                        BackgroundProducerType.valueOf(optionArgs[0]);
```

```
                String[] backgroundOptionArgs = Arrays.copyOfRange(
                    optionArgs, 1, optionArgs.length);
                return parseBackgroundProducer(backgroundProducerType,
                    backgroundOptionArgs, builder);
            } catch (IllegalArgumentException e) {
                throw new ParseException(e.getMessage());
            }
        }

    }

    return builder;
}

private static CaptchaBuilder parseBackgroundProducer(
    BackgroundProducerType backgroundProducerType, String[]
    backgroundProducerOptions, CaptchaBuilder builder) throws
    ParseException {
    BackgroundProducerBuilder backgroundProducerBuilder = new
        BackgroundProducerBuilder(backgroundProducerType);

    if (backgroundProducerOptions.length == 0) {
        //return builder.addBackground(backgroundProducerBuilder.create
            ());
        builder.addBuildSequence(backgroundProducerBuilder);
        return builder;
    }

    if (backgroundProducerOptions.length > BackgroundProducerOptions.
        values().length) {
        throw new ParseException("BackgroundProducer takes a max of " +
            BackgroundProducerOptions.values().length + " arguments");
    }

    for (String backgroundProducerOption : backgroundProducerOptions) {
        if (!backgroundProducerOption.isEmpty()) {
            try {
                String[] optionArgs = backgroundProducerOption.split(
                    CaptchaConstants.buildSequenceLvl4Delim);
                BackgroundProducerOptions backgroundProducerOptionType =
                     BackgroundProducerOptions.valueOf(optionArgs[0]);
                String[] backgroundProducerOptionArgs = Arrays.
                    copyOfRange(optionArgs, 1, optionArgs.length);
                backgroundProducerBuilder =
                    parseBackgroundProducerOption(
                    backgroundProducerOptionType,
                    backgroundProducerOptionArgs,
                    backgroundProducerBuilder);
            } catch (IllegalArgumentException e) {
                throw new ParseException(e.getMessage());
            }
        }

    }

    //return builder.addBackground(backgroundProducerBuilder.create());
    builder.addBuildSequence(backgroundProducerBuilder);
    return builder;
}

private static BackgroundProducerBuilder parseBackgroundProducerOption(
    BackgroundProducerOptions backgroundProducerOptionType, String[]
```

```
        backgroundProducerOptionArgs, BackgroundProducerBuilder
        backgroundProducerBuilder) throws ParseException {
        if (backgroundProducerOptionArgs.length != 1) {
            throw new ParseException("BackgroundProducer option " +
                backgroundProducerOptionType.name() + " only takes 1
                argument");
        }

        String[] colorArgs = backgroundProducerOptionArgs[0].split(
            CaptchaConstants.buildSequenceIvl5Delim);

        switch (backgroundProducerOptionType) {
            case COLORS1:
                try {
                    return backgroundProducerBuilder.setColorRange1(
                        ColorsParser.parse(colorArgs));
                } catch (NumberFormatException e) {
                    throw new ParseException("Background colors1 has invalid
                        formatted numbers");
                }
            case COLORS2:
                try {
                    return backgroundProducerBuilder.setColorRange2(
                        ColorsParser.parse(colorArgs));
                } catch (NumberFormatException e) {
                    throw new ParseException("Background colors2 has invalid
                        formatted numbers");
                }
            default:
                throw new ParseException("BackgroundProducer option not
                    found: " + backgroundProducerOptionType.name());
        }
    }

    enum BackgroundProducerOptions {

        COLORS1,
        COLORS2;
    }
}
```

Listing A.3: captchabuilder.builder.BorderParser

```
/*
 * The MIT License
 *
 * Copyright 2013 piva.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
```

```
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.builder;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.border.BorderProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    producer.BorderProducerType;
import java.util.Arrays;
import org.apache.commons.cli.ParseException;

/**
 * BorderParser.java (UTF-8)
 *
 * Parses the string arguments for rendering a border
 *
 * 2013/04/17
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.8
 * @version 1.0.13
 */
public class BorderParser {

    /**
     * Parses the string arguments for rendering a border, creates a
     * BorderProducer and passes it to the CaptchaBuilder
     *
     * @param borderOptions the string arguments for building a border
     * @param builder the CaptchaBuilder Object to be modified
     * @return a modified CaotchaBuilder object
     * @throws ParseException
     * @see CaptchaBuilder
     */
    public static CaptchaBuilder parse(String[] borderOptions,
        CaptchaBuilder builder) throws ParseException {
        if (borderOptions.length == 0) {
            //return builder.addBorder();
            builder.addBuildSequence(new BorderProducerBuilder(
                BorderProducerType.SOLID));
            return builder;
        }

        if (borderOptions.length > 1) {
            throw new ParseException("Border takes a max of 1 arguments");
        }

        for (String borderOption : borderOptions) {
```

```
            if (!borderOption.isEmpty()) {
                try {
                    String[] optionArgs = borderOption.split(
                        CaptchaConstants.buildSequencelvl3Delim);
                    BorderProducerType borderProducerType =
                        BorderProducerType.valueOf(optionArgs[0]);
                    String[] borderOptionArgs = Arrays.copyOfRange(
                        optionArgs, 1, optionArgs.length);
                    return parseBorderProducer(borderProducerType,
                        borderOptionArgs, builder);
                } catch (IllegalArgumentException e) {
                    throw new ParseException(e.getMessage());
                }
            }
        }

        return builder;
    }

    private static CaptchaBuilder parseBorderProducer(BorderProducerType
        borderProducerType, String[] borderProducerOptions, CaptchaBuilder
        builder) throws ParseException {
        BorderProducerBuilder borderProducerBuilder = new
            BorderProducerBuilder(borderProducerType);

        if (borderProducerOptions.length == 0) {
            //return builder.addBorder(borderProducerBuilder.create());
            builder.addBuildSequence(borderProducerBuilder);
            return builder;
        }

        if (borderProducerOptions.length > BorderProducerOptions.values().
            length) {
            throw new ParseException("BorderProducer takes a max of " +
                BorderProducerOptions.values().length + " arguments");
        }

        for (String boderproducerOption : borderProducerOptions) {
            if (!boderproducerOption.isEmpty()) {
                try {
                    String[] optionArgs = boderproducerOption.split(
                        CaptchaConstants.buildSequencelvl4Delim);
                    BorderProducerOptions borderProducerOptionType =
                        BorderProducerOptions.valueOf(optionArgs[0]);
                    String[] borderProducerOptionArgs = Arrays.copyOfRange(
                        optionArgs, 1, optionArgs.length);
                    borderProducerBuilder = parseBorderProducerOption(
                        borderProducerOptionType, borderProducerOptionArgs,
                        borderProducerBuilder);
                } catch (IllegalArgumentException e) {
                    throw new ParseException(e.getMessage());
                }
            }

        }

        //return builder.addBorder(borderProducerBuilder.create());
        builder.addBuildSequence(borderProducerBuilder);
        return builder;
    }
```

```
    private static BorderProducerBuilder parseBorderProducerOption(
        BorderProducerOptions borderProducerOptionType, String[]
        borderProducerOptionArgs, BorderProducerBuilder
        borderProducerBuilder) throws ParseException {
        if (borderProducerOptionArgs.length != 1) {
            throw new ParseException("BorderProducer option " +
                borderProducerOptionType.name() + " only takes 1 argument");
        }

        switch (borderProducerOptionType) {
            case COLORS:
                try {
                    String[] colorArgs = borderProducerOptionArgs[0].split(
                        CaptchaConstants.buildSequenceIvl5Delim);
                    return borderProducerBuilder.setColorRange(ColorsParser.
                        parse(colorArgs));
                } catch (NumberFormatException e) {
                    throw new ParseException("Border colors has invalid
                        formatted numbers");
                }
            case THICKNESS:
                try {
                    return borderProducerBuilder.setThickness(Integer.
                        parseInt(borderProducerOptionArgs[0]));
                } catch (NumberFormatException e) {
                    throw new ParseException("Border thickness argument has
                        an invalid number format");
                }
            default:
                throw new ParseException("BorderProducer option not found: "
                     + borderProducerOptionType.name());

        }
    }

    enum BorderProducerOptions {

        COLORS,
        THICKNESS;
    }
}
```

Listing A.4: captchabuilder.builder.CaptchaBuilder

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
```

```
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.builder;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background.BackgroundProducer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background.BackgroundProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.border.BorderProducer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise.NoiseProducer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text.TextProducer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.Captcha;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.CaptchaElementCreatorBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy.GimpyRenderer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text.WordRenderer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    producer.BackgroundProducerType;
import java.awt.AlphaComposite;
import java.awt.Graphics2D;
import java.awt.image.BufferedImage;
import java.util.ArrayDeque;
import java.util.Date;
import org.apache.commons.cli.ParseException;

/**
 * CaptchaBuilder.java (UTF-8)
 *
 * Builder class to create Captcha objects.
 *
 * 2013/04/17
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.7
 * @version 1.0.13
 */
public class CaptchaBuilder {

    private BufferedImage img;
    private BufferedImage bg;
    private boolean caseSensative;
    private String answer;
    private String buildSequence;
    private ArrayDeque<CaptchaElementCreatorBuilder> builders;
```

```
    /**
     * Constructor
     *
     * @param width the width of the captcha to be created
     * @param height the width of the captcha to be created
     * @param buildSequence string arguments to create the captcha
     * @throws ParseException
     */
    public CaptchaBuilder(int width, int height, String buildSequence)
        throws ParseException {
        this.builders = new ArrayDeque<>();
        this.setBuildSequence(buildSequence);
        img = new BufferedImage(width, height, BufferedImage.TYPE_INT_ARGB);
        answer = "";
    }

    protected CaptchaBuilder addBackground(BackgroundProducer
        backgroundProducer) {
        bg = backgroundProducer.getBackground(img.getWidth(), img.getHeight
            ());
        return this;
    }

    protected CaptchaBuilder addText(TextProducer textProducer, WordRenderer
         wordRenderer) {
        answer += textProducer.getText();
        wordRenderer.render(answer, img);
        return this;
    }

    protected CaptchaBuilder addNoise(NoiseProducer noiseProducer) {
        noiseProducer.makeNoise(img);
        return this;
    }

    protected CaptchaBuilder gimp(GimpyRenderer gimpyRenderer) {
        gimpyRenderer.gimp(img);
        return this;
    }

    protected CaptchaBuilder addBorder(BorderProducer borderProducer) {
        borderProducer.addBorder(img);
        return this;
    }

    public CaptchaBuilder setImageSize(int width, int height) {
        this.img = new BufferedImage(width, height, BufferedImage.
            TYPE_INT_ARGB);
        return this;
    }

    /**
     * Sets, validates and parses the string arguments for creating the
         captcha.
     *
     * @param buildSequence the string arguments for building a captcha
     * @return the CaptchaBuilder
     * @throws ParseException
     */
    public final CaptchaBuilder setBuildSequence(String buildSequence)
        throws ParseException {
```

```
        if (!buildSequence.equalsIgnoreCase(this.buildSequence)) {
            this.buildSequence = buildSequence.toUpperCase();

            // If the buildSequence has changed then longParse it
            // Before longparsing, empty the elementbuilderDeque
            this.builders.clear();
            // start parsing
            long startTimeLong = System.nanoTime();
            CaptchaBuildSequenceParser.longParse(this);
            long endTimeLong = System.nanoTime();
            double duration = (double) ((endTimeLong - startTimeLong) / Math
                .pow(10, 9));
            System.out.println("Long buildSequence parsed in " + duration +
                " seconds");
        }

        return this;
    }

    private Captcha build() {
        return new Captcha(buildSequence, answer, caseSensative,
            flattenImage(), new Date());
    }

    /**
     * parses the buildstring and creates the captcha.
     *
     * @return a captcha object
     * @throws ParseException
     * @see Captcha
     */
    public Captcha buildCaptcha() throws ParseException {
        img = new BufferedImage(img.getWidth(), img.getHeight(),
            BufferedImage.TYPE_INT_ARGB);
        answer = "";
        long startTimeShort = System.nanoTime();
        CaptchaBuildSequenceParser.shortParse(this);
        long endTimeShort = System.nanoTime();
        double duration = (double) ((endTimeShort - startTimeShort) / Math.
            pow(10, 9));
        System.out.println("Short buildSequence parsed in " + duration + "
            seconds");

        return build();
    }

    public int getWidth() {
        return img.getWidth();
    }

    public int getHeight() {
        return img.getHeight();
    }

    public String getBuildSequence() {
        return buildSequence;
    }

    public final ArrayDeque<CaptchaElementCreatorBuilder> getBuilders() {
        return builders;
    }
```

```
    public void addBuildSequence(CaptchaElementCreatorBuilder elementBuilder
        ) {
        builders.offer(elementBuilder);
    }

    private BufferedImage flattenImage() {
        BufferedImage rImage;
        if (bg == null) {
            rImage = new BackgroundProducerBuilder(BackgroundProducerType.
                TRANSPARENT).create().getBackground(img.getWidth(), img.
                getHeight());
        } else {
            rImage = bg;
        }

        // Paint the main image over the background
        Graphics2D g = rImage.createGraphics();
        g.setComposite(AlphaComposite.getInstance(AlphaComposite.SRC_OVER,
            1.0f));
        g.drawImage(img, null, null);

        return rImage;
    }
}
```

Listing A.5: captchabuilder.builder.CaptchaBuildSequenceParser

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.builder;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background.BackgroundProducer;
```

```
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background.BackgroundProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.border.BorderProducer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.border.BorderProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise.NoiseProducer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise.NoiseProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text.TextProducer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text.TextProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.CaptchaElementCreatorBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy.GimpyRenderer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy.GimpyRendererBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text.WordRenderer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text.WordRendererBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import java.util.ArrayDeque;
import java.util.Arrays;
import org.apache.commons.cli.ParseException;

/**
 * CaptchaBuildSequenceParser.java (UTF-8)
 *
 * receives the buildstring, splits it up it pieces and passes those to the
 * other parsers
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.3
 * @version 1.0.8
 */
public class CaptchaBuildSequenceParser {

    /**
     * Modifies the CaptchaBuilder to store a list of ElementCreatorBuilders
          the parsers made
     * from the buildstring.
     *
     * @param builder the CaptchBuilder object to be modified
     * @throws ParseException
     * @see CaptchaBuilder
     */
    public static void longParse(CaptchaBuilder builder) throws
        ParseException {

        for (String lvl1Arg : builder.getBuildSequence().split(
            CaptchaConstants.buildSequencelvl1Delim)) {
            if (!lvl1Arg.isEmpty()) {
                try {
```

```
                String[] optionArgs = lvl1Arg.split(CaptchaConstants.
                    buildSequencelvl2Delim);
                BuildSequenceOptions buildSequenceOptionType =
                    BuildSequenceOptions.valueOf(optionArgs[0]);
                String[] buildSequenceOptions = Arrays.copyOfRange(
                    optionArgs, 1, optionArgs.length);

                builder = parseBuildSequenceOption(
                    buildSequenceOptionType, buildSequenceOptions,
                    builder);

            } catch (IllegalArgumentException e) {
                throw new ParseException(e.getMessage());
            }
        }
    }
}

private static CaptchaBuilder parseBuildSequenceOption(
    BuildSequenceOptions option, String[] buildSequenceOptions,
    CaptchaBuilder builder) throws ParseException {
    switch (option) {
        case BACKGROUND:
            return BackgroundParser.parse(buildSequenceOptions, builder)
                ;
        case BORDER:
            return BorderParser.parse(buildSequenceOptions, builder);
        case GIMP:
            return GimpyParser.parse(buildSequenceOptions, builder);
        case NOISE:
            return NoiseParser.parse(buildSequenceOptions, builder);
        case TEXT:
            return TextParser.parse(buildSequenceOptions, builder);
        default:
            throw new ParseException("argument not found: " + option.
                name());
    }
}

/**
 * Creates new elementCreators from the list
     CaptchaElementCreatorBuilders
 * in the CaptchaBuilder.
 *
 * @param builder
 * @throws ParseException
 */
public static void shortParse(CaptchaBuilder builder) throws
    ParseException {
    ArrayDeque<CaptchaElementCreatorBuilder> elementBuilders = builder.
        getBuilders().clone();
    ArrayDeque<BuildSequenceOptions> sequence = new ArrayDeque<>();
    for (String lvl1Arg : builder.getBuildSequence().split(
        CaptchaConstants.buildSequencelvl1Delim)) {
        if (!lvl1Arg.isEmpty()) {
            try {
                String[] optionArgs = lvl1Arg.split(CaptchaConstants.
                    buildSequencelvl2Delim);
                sequence.offer(BuildSequenceOptions.valueOf(optionArgs
                    [0]));
            } catch (IllegalArgumentException e) {
                throw new ParseException(e.getMessage());
```

```
                }
            }
        }

        for (BuildSequenceOptions buildSequence : sequence) {
            switch (buildSequence) {
                case BACKGROUND: {
                    CaptchaElementCreatorBuilder elementBuilder =
                        elementBuilders.poll();
                    if (elementBuilder instanceof BackgroundProducerBuilder)
                         {
                        builder.addBackground((BackgroundProducer)
                            elementBuilder.create());
                    } else {
                        throw new ParseException("ShortParse Failed ... How
                            is that possible?\n"
                                + "Class Mismatch: Got " + elementBuilder.
                                    getClass().getSimpleName()
                                + " and expected " +
                                    BackgroundProducerBuilder.class.
                                    getSimpleName());
                    }
                }
                break;
                case BORDER: {
                    CaptchaElementCreatorBuilder elementBuilder =
                        elementBuilders.poll();
                    if (elementBuilder instanceof BorderProducerBuilder) {
                        builder.addBorder((BorderProducer) elementBuilder.
                            create());
                    } else {
                        throw new ParseException("ShortParse Failed ... How
                            is that possible?\n"
                                + "Class Mismatch: Got " + elementBuilder.
                                    getClass().getSimpleName()
                                + " and expected " + BorderProducerBuilder.
                                    class.getSimpleName());
                    }
                }
                break;
                case GIMP: {
                    CaptchaElementCreatorBuilder elementBuilder =
                        elementBuilders.poll();
                    if (elementBuilder instanceof GimpyRendererBuilder) {
                        builder.gimp((GimpyRenderer) elementBuilder.create()
                            );
                    } else {
                        throw new ParseException("ShortParse Failed ... How
                            is that possible?\n"
                                + "Class Mismatch: Got " + elementBuilder.
                                    getClass().getSimpleName()
                                + " and expected " + GimpyRendererBuilder.
                                    class.getSimpleName());
                    }
                }
                break;
                case NOISE: {
                    CaptchaElementCreatorBuilder elementBuilder =
                        elementBuilders.poll();
                    if (elementBuilder instanceof NoiseProducerBuilder) {
                        builder.addNoise((NoiseProducer) elementBuilder.
                            create());
```

```
                    } else {
                        throw new ParseException("ShortParse Failed ... How
                            is that possible?\n"
                                + "Class Mismatch: Got " + elementBuilder.
                                    getClass().getSimpleName()
                                + " and expected " + NoiseProducerBuilder.
                                    class.getSimpleName());
                    }
                }
                break;
                case TEXT: {
                    CaptchaElementCreatorBuilder elementBuilder1 =
                        elementBuilders.poll();
                    CaptchaElementCreatorBuilder elementBuilder2 =
                        elementBuilders.poll();
                    if (elementBuilder1 instanceof TextProducerBuilder &&
                        elementBuilder2 instanceof WordRendererBuilder) {
                        builder.addText((TextProducer) elementBuilder1.
                            create(), (WordRenderer) elementBuilder2.create
                            ());
                    } else {
                        throw new ParseException("ShortParse Failed ... How
                            is that possible?\n"
                                + "Class Mismatch: Got " + elementBuilder1.
                                    getClass().getSimpleName()
                                + " and expected " + TextProducerBuilder.
                                    class.getSimpleName()
                                + "\n"
                                + "Class Mismatch: Got " + elementBuilder2.
                                    getClass().getSimpleName()
                                + " and expected " + WordRendererBuilder.
                                    class.getSimpleName());
                    }
                }
            }
        }
    }

    enum BuildSequenceOptions {

        BACKGROUND,
        BORDER,
        GIMP,
        NOISE,
        TEXT;
    }
}
```

Listing A.6: captchabuilder.builder.ColorsParser

```
/*
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
```

```
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.builder;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ImageUtil;
import java.util.ArrayList;
import java.util.Arrays;
import org.apache.commons.cli.ParseException;

/**
 * ColorsParser.java (UTF-8)
 *
 * Parses the string arguments for rendering colors
 *
 * 2013/04/18
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.8
 * @version 1.1.0
 */
public class ColorsParser {

    /**
     * Returns a ColorRangRGBA based on string arguments
     *
     * @param colorArgs the string arguments
     * @return a ColorRangRGBA object
     * @throws ParseException
     * @see ColorRangeRGBA
     */
    public static ColorRangeRGBA parse(String[] colorArgs) throws
        ParseException {

        System.out.println("parsing colors option: " + Arrays.deepToString(
            colorArgs));
        ColorOptions colorOptionType = ColorOptions.valueOf(colorArgs[0]);

        switch (colorOptionType) {
            case RANGE:
                if (colorArgs.length != 3) {
                    throw new ParseException("Colors range Option only takes
                        2 argumenst");
```

```
                }
                String startHex = "#" + colorArgs[1].toUpperCase();
                String endHex = "#" + colorArgs[2].toUpperCase();
                return new ColorRangeRGBA(ImageUtil.hexadecimalToRGBa(
                    startHex), ImageUtil.hexadecimalToRGBa(endHex));
            case LIST:
                if (colorArgs.length < 2) {
                    throw new ParseException("Colors list Option takes at
                        least 2 argumenst");
                }
                ArrayList<String> hexList = new ArrayList<>();
                for (int i = 1; i < colorArgs.length; i++) {
                    String colorHex = "#"+colorArgs[i].toUpperCase();
                    hexList.add(colorHex);
                }

                return new ColorRangeRGBA(hexList);
            default:
                throw new ParseException("Colors option not found: " +
                    colorOptionType.name());
        }
    }
     enum ColorOptions {

        RANGE,
        LIST;
    }
}
```

Listing A.7: captchabuilder.builder.GimpyParser

```
/*
 * The MIT License
 *
 * Copyright 2013 piva.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
```

```
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.builder;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy.GimpyRendererBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    renderer.GimpyRendererType;
import java.util.Arrays;
import org.apache.commons.cli.ParseException;

/**
 * GimpyParser.java (UTF-8)
 *
 * Parses the string arguments for rendering transformations
 *
 * 2013/04/17
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.8
 * @version 1.0.13
 */
public class GimpyParser {

    /**
     * Parses the string arguments for rendering transformations, creates a
     * GimpyRenderer and passes it to the CaptchaBuilder
     *
     * @param buildSequenceOptions the string arguments for building
     * transformations
     * @param builder the CaptchaBuilder Object to be modified
     * @return a modified CaptchaBuilder object
     * @throws org.apache.commons.cli.ParseException
     * @see CaptchaBuilder
     */
    public static CaptchaBuilder parse(String[] buildSequenceOptions,
        CaptchaBuilder builder) throws ParseException {
        if (buildSequenceOptions.length == 0) {
            //return builder.gimp();
            builder.addBuildSequence(new GimpyRendererBuilder(
                GimpyRendererType.RIPPLE));
            return builder;
        }

        if (buildSequenceOptions.length > GimpyRendererOptions.values().
            length) {
            throw new ParseException("Background takes a max of " +
                GimpyRendererOptions.values().length + " arguments");
        }

        for (String gimpyOption : buildSequenceOptions) {
            if (!gimpyOption.isEmpty()) {
                try {
                    String[] optionArgs = gimpyOption.split(CaptchaConstants
                        .buildSequenceLvl3Delim);
                    GimpyRendererType gimpyRenenderType = GimpyRendererType.
                        valueOf(optionArgs[0]);
                    String[] gimpyOptions = Arrays.copyOfRange(optionArgs,
                        1, optionArgs.length);
```

```
                return parseGimpyRenderer(gimpyRenenderType,
                    gimpyOptions, builder);
            } catch (IllegalArgumentException e) {
                throw new ParseException(e.getMessage());
            }
        }
    }

    return builder;
}

private static CaptchaBuilder parseGimpyRenderer(GimpyRendererType
    gimpyRendererType, String[] gimpyOptions, CaptchaBuilder builder)
    throws ParseException {
    GimpyRendererBuilder gimpyRendererBuilder = new GimpyRendererBuilder
        (gimpyRendererType);

    if (gimpyOptions.length == 0) {
        //return builder.gimp(gimpyRendererBuilder.create());
        builder.addBuildSequence(gimpyRendererBuilder);
        return builder;
    }

    if (gimpyOptions.length > GimpyRendererOptions.values().length) {
        throw new ParseException("BackgroundProducer takes a max of " +
            GimpyRendererOptions.values().length + " arguments");
    }

    for (String gimpyRendererOption : gimpyOptions) {
        String[] optionArgs = gimpyRendererOption.split(CaptchaConstants
            .buildSequencelvl4Delim);
        try {
            GimpyRendererOptions gimpyRendererOptionType =
                GimpyRendererOptions.valueOf(optionArgs[0]);
            String[] gimpyRendererOptionArgs = Arrays.copyOfRange(
                optionArgs, 1, optionArgs.length);
            gimpyRendererBuilder = parseGimpyRendererOption(
                gimpyRendererOptionType, gimpyRendererOptionArgs,
                gimpyRendererBuilder);
        } catch (IllegalArgumentException e) {
            throw new ParseException(e.getMessage());
        }
    }

    //return builder.gimp(gimpyRendererBuilder.create());
    builder.addBuildSequence(gimpyRendererBuilder);
    return builder;
}

private static GimpyRendererBuilder parseGimpyRendererOption(
    GimpyRendererOptions gimpyRendererOptionType, String[]
    gimpyRendererOptionArgs, GimpyRendererBuilder gimpyRendererBuilder)
    throws ParseException {
    if (gimpyRendererOptionArgs.length != 1) {
        throw new ParseException("GimpyRenderer option " +
            gimpyRendererOptionType.name() + " only takes 1 argument");
    }

    String arg = gimpyRendererOptionArgs[0];
    String[] colorArgs;

    switch (gimpyRendererOptionType) {
```

```
            case DOUBLE1:
                try {
                    return gimpyRendererBuilder.setD1(Double.parseDouble(arg
                        ));
                } catch (NumberFormatException e) {
                    throw new ParseException("Gimp double1 argument has an
                        invalid number format");
                }
            case DOUBLE2:
                try {
                    return gimpyRendererBuilder.setD2(Double.parseDouble(arg
                        ));
                } catch (NumberFormatException e) {
                    throw new ParseException("Gimp double2 argument has an
                        invalid number format");
                }
            case COLORS1:
                try {
                    colorArgs = arg.split(CaptchaConstants.
                        buildSequenceIvl5Delim);
                    return gimpyRendererBuilder.setColorRange1(ColorsParser.
                        parse(colorArgs));
                } catch (NumberFormatException e) {
                    throw new ParseException("Gimp colors1 has invalid
                        formatted numbers");
                }
            case COLORS2:
                try {
                    colorArgs = arg.split(CaptchaConstants.
                        buildSequenceIvl5Delim);
                    return gimpyRendererBuilder.setColorRange2(ColorsParser.
                        parse(colorArgs));
                } catch (NumberFormatException e) {
                    throw new ParseException("Border colors2 has invalid
                        formatted numbers");
                }
            default:
                throw new ParseException("GimpyRenderer option not found: "
                    + gimpyRendererOptionType.name());
        }
    }

    enum GimpyOptions {

        DEFAULT;
    }

    enum GimpyRendererOptions {

        DOUBLE1,
        DOUBLE2,
        COLORS1,
        COLORS2;
    }
}
```

Listing A.8: captchabuilder.builder.NoiseParser

```
/*
 * The MIT License
 *
```

```
 * Copyright 2013 piva.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.builder;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise.NoiseProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    producer.NoiseProducerType;
import java.util.Arrays;
import org.apache.commons.cli.ParseException;

/**
 * NoiseParser.java (UTF-8)
 *
 * Parses the string arguments for rendering noise
 *
 * 2013/04/17
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.8
 * @version 1.0.13
 */
public class NoiseParser {

    /**
     * Parses the string arguments for rendering noise, creates a
     * NoiseProducer and passes it to the CaptchaBuilder
     *
     * @param buildSequenceOptions the string arguments for building noise
     * @param builder the CaptchaBuilder Object to be modified
     * @return a modified CaptchaBuilder object
     * @throws org.apache.commons.cli.ParseException
     * @see CaptchaBuilder
```

```
     */
    public static CaptchaBuilder parse(String[] buildSequenceOptions,
        CaptchaBuilder builder) throws ParseException {
        if (buildSequenceOptions.length == 0) {
            //return builder.addNoise();
            builder.addBuildSequence(new NoiseProducerBuilder(
                NoiseProducerType.CURVEDLINE));
            return builder;
        }

        if (buildSequenceOptions.length > NoiseOptions.values().length) {
            throw new ParseException("Noise takes a max of " + NoiseOptions.
                values().length + " arguments");
        }

        for (String noiseOption : buildSequenceOptions) {
            if (!noiseOption.isEmpty()) {
                try {
                    String[] optionArgs = noiseOption.split(CaptchaConstants
                        .buildSequencelvl3Delim);
                    NoiseProducerType bgProdBuilder = NoiseProducerType.
                        valueOf(optionArgs[0]);
                    String[] noiseOptions = Arrays.copyOfRange(optionArgs,
                        1, optionArgs.length);
                    return parseNoiseProducer(bgProdBuilder, noiseOptions,
                        builder);
                } catch (IllegalArgumentException e) {
                    throw new ParseException(e.getMessage());
                }
            }
        }

        return builder;
    }

    private static CaptchaBuilder parseNoiseProducer(NoiseProducerType
        noiseProducerType, String[] noiseProducerOptions, CaptchaBuilder
        builder) throws ParseException {
        NoiseProducerBuilder noiseProducerBuilder = new NoiseProducerBuilder
            (noiseProducerType);

        if (noiseProducerOptions.length == 0) {
            //return builder.addNoise(noiseProducerBuilder.create());
            builder.addBuildSequence(noiseProducerBuilder);
            return builder;
        }

        if (noiseProducerOptions.length > NoiseProducerOptions.values().
            length) {
            throw new ParseException("NoiseProducer takes a max of " +
                NoiseProducerOptions.values().length + " arguments");
        }

        for (String noiseProducerOption : noiseProducerOptions) {
            String[] optionArgs = noiseProducerOption.split(CaptchaConstants
                .buildSequencelvl4Delim);
            try {
                NoiseProducerOptions noiseProducerOptionType =
                    NoiseProducerOptions.valueOf(optionArgs[0]);
                String[] noiseProducerOptionArgs = Arrays.copyOfRange(
                    optionArgs, 1, optionArgs.length);
```

```
                noiseProducerBuilder = parseNoiseProducerOption(
                    noiseProducerOptionType, noiseProducerOptionArgs,
                    noiseProducerBuilder);
            } catch (IllegalArgumentException e) {
                throw new ParseException(e.getMessage());
            }
        }

        //return builder.addNoise(noiseProducerBuilder.create());
        builder.addBuildSequence(noiseProducerBuilder);
        return builder;
    }

    private static NoiseProducerBuilder parseNoiseProducerOption(
        NoiseProducerOptions noiseProducerOptionType, String[]
        noiseProducerOptionArgs, NoiseProducerBuilder noiseProducerBuilder)
        throws ParseException {
        if (noiseProducerOptionArgs.length != 1) {
            throw new ParseException("NoiseProducer option " +
                noiseProducerOptionType.name() + " only takes 1 argument");
        }

        switch (noiseProducerOptionType) {
            case COLORS:
                try {
                    return noiseProducerBuilder.setColorRange(ColorsParser.
                        parse(noiseProducerOptionArgs[0].split(
                        CaptchaConstants.buildSequencelvl5Delim)));
                } catch (NumberFormatException e) {
                    throw new ParseException("Noise colors has invalid
                        formatted numbers");
                }
            case THICKNESS:
                try {
                    return noiseProducerBuilder.setThickness(Float.
                        parseFloat(noiseProducerOptionArgs[0]));
                } catch (NumberFormatException e) {
                    throw new ParseException("Noise thickness argument has
                        an invalid number format");
                }
            default:
                throw new ParseException("NoiseProducer option not found: "
                    + noiseProducerOptionType.name());
        }
    }

    enum NoiseOptions {

        DEFAULT;
    }

    enum NoiseProducerOptions {

        COLORS,
        THICKNESS;
    }
}
```

Listing A.9: captchabuilder.builder.TextParser

```
/*
```

```
 * The MIT License
 *
 * Copyright 2013 piva.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.builder;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text.TextProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text.WordRendererBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    producer.TextProducerType;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    renderer.WordRendererType;
import java.awt.Font;
import java.util.ArrayList;
import java.util.Arrays;
import org.apache.commons.cli.ParseException;

/**
 * TextParser.java (UTF-8)
 *
 * Parses the string arguments for creating the text
 *
 * 2013/04/18
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.8
 * @version 1.0.13
 */
public class TextParser {
```

```
    private static TextProducerBuilder textProducerBuilder = new
        TextProducerBuilder(TextProducerType.REDUCED_ALPHANUMERIC);
    private static WordRendererBuilder wordRendererBuilder = new
        WordRendererBuilder(WordRendererType.DEFAULT);

    /**
     * Parses the string arguments for rendering Text, creates a
     * TextProducer and WordRenderer passes these to the CaptchaBuilder
     *
     * @param buildSequenceOptions the string arguments for adding text
     * @param builder the CaptchaBuilder Object to be modified
     * @return a modified CaptchaBuilder object
     * @throws org.apache.commons.cli.ParseException
     * @see CaptchaBuilder
     */
    public static CaptchaBuilder parse(String[] buildSequenceOptions,
        CaptchaBuilder builder) throws ParseException {

        for (String textOptionArg : buildSequenceOptions) {
            if (!textOptionArg.isEmpty()) {
                try {
                    String[] optionArgs = textOptionArg.split(
                        CaptchaConstants.buildSequencelvl3Delim);
                    TextOptions textOptionType = TextOptions.valueOf(
                        optionArgs[0]);
                    String[] textOptions = Arrays.copyOfRange(optionArgs, 1,
                         optionArgs.length);

                    parseTextOption(textOptionType, textOptions, builder);
                } catch (IllegalArgumentException e) {
                    throw new ParseException(e.getMessage());
                }

            }
        }

        //return builder.addText(textProducerBuilder.create(),
            wordRendererBuilder.create());
        builder.addBuildSequence(textProducerBuilder);
        builder.addBuildSequence(wordRendererBuilder);
        return builder;
    }

    private static void parseTextOption(TextOptions textOptionType, String[]
         textOptions, CaptchaBuilder builder) throws ParseException {

        switch (textOptionType) {
            case TEXTPRODUCER:
                textProducerBuilder = TextProducerParser.parse(textOptions,
                    textProducerBuilder);
                break;
            case WORDRENDERER:
                wordRendererBuilder = WordRendererParser.parse(textOptions,
                    wordRendererBuilder);
                break;
            default:
                throw new ParseException("Text argument not found: " +
                    textOptionType.name());
        }
    }

    private static class TextProducerParser {
```

```
    private static TextProducerBuilder parse(String[]
        textProducerOptions, TextProducerBuilder builder) throws
        ParseException {
        if (textProducerOptions.length == 0) {
            builder = new TextProducerBuilder(TextProducerType.
                REDUCED_ALPHANUMERIC);
        }

        if (textProducerOptions.length > 1) {
            throw new ParseException("TextProducer takes a max of 1
                argument");
        }

        for (String textProducerOption : textProducerOptions) {
            if (!textProducerOption.isEmpty()) {
                String[] optionArgs = textProducerOption.split(
                    CaptchaConstants.buildSequencelvl4Delim);
                TextProducerType textProducerType = TextProducerType.
                    valueOf(optionArgs[0]);
                String[] textProducerOptionArgs = Arrays.copyOfRange(
                    optionArgs, 1, optionArgs.length);

                builder = new TextProducerBuilder(textProducerType);
                builder = parseTextProducerOption(textProducerType,
                    textProducerOptionArgs, builder);
            }
        }

        return builder;
    }

    private static TextProducerBuilder parseTextProducerOption(
        TextProducerType textProducerType, String[]
        textProducerOptionArgs, TextProducerBuilder builder) throws
        ParseException {
        if (textProducerOptionArgs.length == 0) {
            builder = new TextProducerBuilder(textProducerType);
        }

        if (textProducerOptionArgs.length > TextProducerOptions.values()
            .length) {
            throw new ParseException("TextProducerType takes a max of "
                + TextProducerOptions.values().length + " arguments");
        }

        for (String textProducerTypeOption : textProducerOptionArgs) {
            if (!textProducerTypeOption.isEmpty()) {
                String[] optionArgs = textProducerTypeOption.split(
                    CaptchaConstants.buildSequencelvl5Delim);
                TextProducerOptions textProducerOptionType =
                    TextProducerOptions.valueOf(optionArgs[0]);
                String[] textProducerTypeOptionArgs = Arrays.copyOfRange
                    (optionArgs, 1, optionArgs.length);

                builder = parseTextProducerTypeOption(
                    textProducerOptionType, textProducerTypeOptionArgs,
                    builder);
            }
        }

        return builder;
```

```
        }

        private static TextProducerBuilder parseTextProducerTypeOption(
            TextProducerOptions textProducerOptionType, String[]
            textProducerTypeOptionArgs, TextProducerBuilder builder) throws
            ParseException {
            if (textProducerTypeOptionArgs.length != 1) {
                throw new ParseException("TextProducerOption " +
                    textProducerOptionType.name() + " only takes one
                    argument");
            }

            switch (textProducerOptionType) {
                case MINLENGTH:
                    try {
                        return builder.setMinLenght(Integer.parseInt(
                            textProducerTypeOptionArgs[0]));
                    } catch (NumberFormatException e) {
                        throw new ParseException("Text TextProducer
                            MinLength argument has an invalid number format"
                            );
                    }
                case MAXLENGTH:
                    try {
                        return builder.setMaxLenght(Integer.parseInt(
                            textProducerTypeOptionArgs[0]));
                    } catch (NumberFormatException e) {
                        throw new ParseException("Text TextProducer
                            MaxLength argument has an invalid number format"
                            );
                    }
                default:
                    throw new ParseException("TextProducerOptionType not
                        found: " + textProducerOptionType.name());
            }
        }
    }

    private static class WordRendererParser {

        private static WordRendererBuilder parse(String[]
            wordRendererOptions, WordRendererBuilder builder) throws
            ParseException {
            if (wordRendererOptions.length == 0) {
                builder = new WordRendererBuilder(WordRendererType.DEFAULT);
            }

            if (wordRendererOptions.length > 1) {
                throw new ParseException("WordRenderer takes a max of 1
                    argument");
            }

            for (String wordRendererOption : wordRendererOptions) {
                if (!wordRendererOption.isEmpty()) {
                    String[] optionArgs = wordRendererOption.split(
                        CaptchaConstants.buildSequencelvl4Delim);
                    WordRendererType wordRendererType = WordRendererType.
                        valueOf(optionArgs[0]);
                    String[] wordRendererOptionArgs = Arrays.copyOfRange(
                        optionArgs, 1, optionArgs.length);
```

```
                builder = parseWordRendererOption(wordRendererType,
                    wordRendererOptionArgs, builder);
            }
        }

        return builder;
    }

    private static WordRendererBuilder parseWordRendererOption(
        WordRendererType wordRendererType, String[]
        wordRendererOptionArgs, WordRendererBuilder builder) throws
        ParseException {
        if (wordRendererOptionArgs.length == 0) {
            return builder;
        }

        if (wordRendererOptionArgs.length > WordRendererOptions.values()
            .length) {
            throw new ParseException("WordRendererType takes a max of "
                + WordRendererOptions.values().length + " arguments");
        }

        for (String wordRendererTypeOption : wordRendererOptionArgs) {
            if (!wordRendererTypeOption.isEmpty()) {
                String[] optionArgs = wordRendererTypeOption.split(
                    CaptchaConstants.buildSequenceIvl5Delim);
                WordRendererOptions wordRendererOptionType =
                    WordRendererOptions.valueOf(optionArgs[0]);
                String[] wordRendererTypeOptionArgs = Arrays.copyOfRange
                    (optionArgs, 1, optionArgs.length);

                builder = parseWordRendererTypeOption(
                    wordRendererOptionType, wordRendererTypeOptionArgs,
                    builder);
            }
        }

        return builder;
    }

    private static WordRendererBuilder parseWordRendererTypeOption(
        WordRendererOptions wordRendererOptionType, String[]
        wordRendererTypeOptionArgs, WordRendererBuilder builder) throws
        ParseException {
        switch (wordRendererOptionType) {
            case COLORS:
                try {
                    if (wordRendererTypeOptionArgs.length != 1) {
                        throw new ParseException("WordRendererOption " +
                             wordRendererOptionType.name() + " only
                            takes one argument");
                    }
                    String[] colorArgs = wordRendererTypeOptionArgs[0].
                        split(CaptchaConstants.buildSequenceIvl6Delim);
                    return builder.setColorRange(ColorsParser.parse(
                        colorArgs));
                } catch (NumberFormatException e) {
                    throw new ParseException("Text WordRenderer colors
                        has invalid formatted numbers");
                }
            case FONTS:
                if (wordRendererTypeOptionArgs.length < 1) {
```

```
                    throw new ParseException("WordRendererOption " +
                        wordRendererOptionType.name() + " only takes one
                        argument");
                }
                ArrayList<Font> fonts = new ArrayList<>();
                for (String fontString : wordRendererTypeOptionArgs) {
                    String[] fontArgs = fontString.split(
                        CaptchaConstants.buildSequenceIvl6Delim);
                    fonts.add(new Font(fontArgs[0], Integer.parseInt(
                        fontArgs[1]), Integer.parseInt(fontArgs[2])));
                }
                return builder.setFonts(fonts);
            case STROKE:
                if (wordRendererTypeOptionArgs.length != 1) {
                    throw new ParseException("WordRendererOption " +
                        wordRendererOptionType.name() + " only takes one
                        argument");
                }
                try {
                    return builder.setStrokeWidth(Float.parseFloat(
                        wordRendererTypeOptionArgs[0]));
                } catch (NumberFormatException e) {
                    throw new ParseException("Text WordRenderer Stroke
                        argument has an invalid number format");
                }
            case XOFF:
                if (wordRendererTypeOptionArgs.length != 1) {
                    throw new ParseException("WordRendererOption " +
                        wordRendererOptionType.name() + " only takes one
                        argument");
                }
                try {
                    return builder.setXOffset(Double.parseDouble(
                        wordRendererTypeOptionArgs[0]));
                } catch (NumberFormatException e) {
                    throw new ParseException("Text WordRenderer XOFF
                        argument has an invalid number format");
                }
            case YOFF:
                if (wordRendererTypeOptionArgs.length != 1) {
                    throw new ParseException("WordRendererOption " +
                        wordRendererOptionType.name() + " only takes one
                        argument");
                }
                try {
                    return builder.setYOffset(Double.parseDouble(
                        wordRendererTypeOptionArgs[0]));
                } catch (NumberFormatException e) {
                    throw new ParseException("Text WordRenderer YOFF
                        argument has an invalid number format");
                }
            default:
                throw new ParseException("WordRendeereOptionType not
                    found: " + wordRendererOptionType.name());
        }
    }
}

enum TextOptions {

    TEXTPRODUCER,
    WORDRENDERER;
```

```
    }

    enum TextProducerOptions {

        MINLENGTH,
        MAXLENGTH;
    }

    enum WordRendererOptions {

        COLORS,
        FONTS,
        STROKE,
        XOFF,
        YOFF;
    }

    enum FontOptions {

        FONTNAME,
        FONTSTYLE,
        FONTSIZE;
    }
}
```

Listing A.10: captchabuilder.elementcreator.CaptchaElementCreatorBuilder

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator;

/**
```

```
 * CaptchaElementCreatorBuilder.java (UTF-8)
 *
 * Builder for element creators
 *
 * 2013/04/18
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.15
 * @version 1.1.0
 */
public interface CaptchaElementCreatorBuilder<T> {

    /**
     * creates an element creator
     *
     * @return element creator object
     */
    public T create();
}
```

A.11 Package captchabuilder.elementcreator.producer

A.12 Package captchabuilder.elementcreator.renderer

Listing A.11: captchabuilder.util.ArrayUtil

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
```

```
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util;

import java.util.Arrays;

/**
 * ArrayUtil.java (UTF-8)
 *
 * utility for array operations
 *
 * 2013/04/15
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.2
 * @version 1.0.2
 */
public abstract class ArrayUtil<T> {

    /**
     * Conactenates the arrays past as arguments.
     *
     * @param <T> the class of the objects inside the arrays.
     * @param first the first array
     * @param rest the following arrays
     * @return a new array comprising the ones passed as arguments
     */
    @SuppressWarnings("unchecked")
    public static <T> T[] concat(T[] first, T[]... rest) {
        int totalLength = first.length;
        for (T[] array : rest) {
            totalLength += array.length;
        }
        T[] result = Arrays.copyOf(first, totalLength);
        int offset = first.length;
        for (T[] array : rest) {
            System.arraycopy(array, 0, result, offset, array.length);
            offset += array.length;
        }
        return result;
    }

    /**
     * Conactenates the arrays past as arguments.
     *
     * @param first the first array
     * @param rest the following arrays
     * @return a new array comprising the ones passed as arguments
     */
    public static char[] concat(char[] first, char[]... rest) {
        int totalLength = first.length;
        for (char[] array : rest) {
            totalLength += array.length;
        }
        char[] result = Arrays.copyOf(first, totalLength);
        int offset = first.length;
        for (char[] array : rest) {
            System.arraycopy(array, 0, result, offset, array.length);
            offset += array.length;
        }
```

```
        return result;
    }

    /**
     * Conactenates the arrays past as arguments.
     *
     * @param first the first array
     * @param rest the following arrays
     * @return a new array comprising the ones passed as arguments
     */
    public static int[] concat(int[] first, int[]... rest) {
        int totalLength = first.length;
        for (int[] array : rest) {
            totalLength += array.length;
        }
        int[] result = Arrays.copyOf(first, totalLength);
        int offset = first.length;
        for (int[] array : rest) {
            System.arraycopy(array, 0, result, offset, array.length);
            offset += array.length;
        }
        return result;
    }

    /**
     * Conactenates the arrays past as arguments.
     *
     * @param first the first array
     * @param rest the following arrays
     * @return a new array comprising the ones passed as arguments
     */
    public static double[] concat(double[] first, double[]... rest) {
        int totalLength = first.length;
        for (double[] array : rest) {
            totalLength += array.length;
        }
        double[] result = Arrays.copyOf(first, totalLength);
        int offset = first.length;
        for (double[] array : rest) {
            System.arraycopy(array, 0, result, offset, array.length);
            offset += array.length;
        }
        return result;
    }

    /**
     * Conactenates the arrays past as arguments.
     *
     * @param first the first array
     * @param rest the following arrays
     * @return a new array comprising the ones passed as arguments
     */
    public static float[] concat(float[] first, float[]... rest) {
        int totalLength = first.length;
        for (float[] array : rest) {
            totalLength += array.length;
        }
        float[] result = Arrays.copyOf(first, totalLength);
        int offset = first.length;
        for (float[] array : rest) {
            System.arraycopy(array, 0, result, offset, array.length);
            offset += array.length;
```

```
        }
        return result;
    }

    /**
     * Conactenates the arrays past as arguments.
     *
     * @param first the first array
     * @param rest the following arrays
     * @return a new array comprising the ones passed as arguments
     */
    public static byte[] concat(byte[] first, byte[]... rest) {
        int totalLength = first.length;
        for (byte[] array : rest) {
            totalLength += array.length;
        }
        byte[] result = Arrays.copyOf(first, totalLength);
        int offset = first.length;
        for (byte[] array : rest) {
            System.arraycopy(array, 0, result, offset, array.length);
            offset += array.length;
        }
        return result;
    }

    /**
     * Conactenates the arrays past as arguments.
     *
     * @param first the first array
     * @param rest the following arrays
     * @return a new array comprising the ones passed as arguments
     */
    public static short[] concat(short[] first, short[]... rest) {
        int totalLength = first.length;
        for (short[] array : rest) {
            totalLength += array.length;
        }
        short[] result = Arrays.copyOf(first, totalLength);
        int offset = first.length;
        for (short[] array : rest) {
            System.arraycopy(array, 0, result, offset, array.length);
            offset += array.length;
        }
        return result;
    }

    /**
     * Conactenates the arrays past as arguments.
     *
     * @param first the first array
     * @param rest the following arrays
     * @return a new array comprising the ones passed as arguments
     */
    public static long[] concat(long[] first, long[]... rest) {
        int totalLength = first.length;
        for (long[] array : rest) {
            totalLength += array.length;
        }
        long[] result = Arrays.copyOf(first, totalLength);
        int offset = first.length;
        for (long[] array : rest) {
            System.arraycopy(array, 0, result, offset, array.length);
```

```
            offset += array.length;
        }
        return result;
    }

    /**
     * Conactenates the arrays past as arguments.
     *
     * @param first the first array
     * @param rest the following arrays
     * @return a new array comprising the ones passed as arguments
     */
    public static boolean[] concat(boolean[] first, boolean[]... rest) {
        int totalLength = first.length;
        for (boolean[] array : rest) {
            totalLength += array.length;
        }
        boolean[] result = Arrays.copyOf(first, totalLength);
        int offset = first.length;
        for (boolean[] array : rest) {
            System.arraycopy(array, 0, result, offset, array.length);
            offset += array.length;
        }
        return result;
    }
}
```

Listing A.12: captchabuilder.util.CaptchaDAO

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util;
```

```
import java.awt.image.BufferedImage;

/**
 * CaptchaDAO.java (UTF-8)
 *
 * A data access object were all data is read only, used to pass the captcha
 * info to a GUI
 *
 * 2013/04/15
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.2.0
 * @version 1.2.0
 */
public class CaptchaDAO {
    private final BufferedImage image;
    private final String answer;
    private final String parserMessage;

    /**
     * Constructor
     *
     * @param image the generated image
     * @param answer the answer
     * @param parserMessage the message the parse generated
     */
    public CaptchaDAO(BufferedImage image, String answer, String
        parserMessage) {
        this.image = image;
        this.answer = answer;
        this.parserMessage = parserMessage;
    }

    public BufferedImage getImage() {
        return image;
    }

    public String getAnswer() {
        return answer;
    }

    public String getParserMessage() {
        return parserMessage;
    }
}
```

Listing A.13: captchabuilder.util.ColorRangeRGBA

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
```

```
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import java.awt.Color;
import java.util.List;
import java.util.Random;

/**
 * ColorRangeRGBA.java (UTF-8)
 *
 * usage and functionality here
 *
 * 2013/04/19
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.1.0
 * @version 1.1.0
 */
public class ColorRangeRGBA {

    private final int startR;
    private final int endR;
    private final int startG;
    private final int endG;
    private final int startB;
    private final int endB;
    private final int startA;
    private final int endA;
    private Random random;
    private boolean listMode;
    private List<String> hexList;

    /**
     * Constructor
     *
     * @param MSa a colour in MSaccess format
     */
    public ColorRangeRGBA(int MSa) {
        this(MSa, MSa);
    }
```

```
/**
 * constructor
 *
 * @param hexList a list of colours in hexadecimal form
 */
public ColorRangeRGBA(List<String> hexList) {
    this(0);
    this.listMode = true;
    this.hexList = hexList;
}

/**
 * constructor
 *
 * @param rgba a collection of colours in RGBA format
 */
public ColorRangeRGBA(int[] rgba) {
    this(rgba, rgba);
}

/**
 * Constructor
 *
 * @param r a colour's red value
 * @param g a colour's green value
 * @param b a colour's blue value
 */
public ColorRangeRGBA(int r, int g, int b) {
    this(r, g, b, 0);
}

/**
 * constructor
 *
 * @param r a colour's red value
 * @param g a colour's green value
 * @param b a colour's blue value
 * @param a a colour's alpha value
 */
public ColorRangeRGBA(int r, int b, int g, int a) {
    this(r, r, g, g, g, g, a, a);
}

/**
 * constructor
 *
 * @param startRGBa the start of a colour range in RGBa format
 * @param endRGBa the end of a colour range in RGBa format
 */
public ColorRangeRGBA(int[] startRGBa, int[] endRGBa) {
    this(startRGBa[0], endRGBa[0], startRGBa[1], endRGBa[1], startRGBa
        [2], endRGBa[2], startRGBa[3], endRGBa[3]);
}

/**
 * constructor
 *
 * @param startMSa the start of a colour range in MSAcces format
 * @param endMSa the start of a colour range in MSAcces format
 */
public ColorRangeRGBA(int startMSa, int endMSa) {
```

```
        this(ImageUtil.msAccesToRGBa(startMSa), ImageUtil.msAccesToRGBa(
            endMSa));
    }

    /**
     * constructor
     *
     * @param startR the start of a colour range red value
     * @param endR the end of a colour range red value
     * @param startG the start of a colour range green value
     * @param endG the end of a colour range green value
     * @param startB the start of a colour range blue value
     * @param endB the end of a colour range blue value
     * @param startA the start of a colour range alpha value
     * @param endA the end of a colour range red value
     */
    public ColorRangeRGBA(int startR, int endR, int startG, int endG, int
        startB, int endB, int startA, int endA) {
        this.random = CaptchaConstants.RANDOM;
        this.startR = startR;
        this.endR = endR;
        this.startG = startG;
        this.endG = endG;
        this.startB = startB;
        this.endB = endB;
        this.startA = startA;
        this.endA = endA;
        this.listMode = false;
    }

    /**
     * picks a random colour in the range and returns it
     *
     * @return a colour object
     */
    public Color getRandomColorInRange() {
        return new Color(getRandomInRangeR(), getRandomInRangeG(),
            getRandomInRangeB(), getRandomInRangeA());
    }

    /**
     * picks a random colour in the range and returns it
     *
     * @return a colour in MSAcces format
     */
    public int getRandomMSaccesInRange() {
        return ImageUtil.rgbToMsAcces(getRandomInRangeR(), getRandomInRangeG
            (), getRandomInRangeB());
    }

    private int getRandomInRangeR() {
        if (listMode) {
            return ImageUtil.hexadecimalToRGBa(hexList.get(random.nextInt(
                hexList.size())))[0];
        } else {
            return random8bitNumber(startR, endR);
        }
    }

    private int getRandomInRangeG() {
        if (listMode) {
```

```
            return ImageUtil.hexadecimalToRGBa(hexList.get(random.nextInt(
                hexList.size())))[1];
        } else {
            return random8bitNumber(startG, endG);
        }
    }

    private int getRandomInRangeB() {
        if (listMode) {
            return ImageUtil.hexadecimalToRGBa(hexList.get(random.nextInt(
                hexList.size())))[2];
        } else {
            return random8bitNumber(startB, endB);
        }
    }

    private int getRandomInRangeA() {
        if (listMode) {
            return ImageUtil.hexadecimalToRGBa(hexList.get(random.nextInt(
                hexList.size())))[3];
        } else {
            return random8bitNumber(startA, endA);
        }
    }

    private int random8bitNumber(int start, int end) {
        if (start > end) {
            if (random.nextBoolean()) {
                return random8bitNumber(0, end);
            } else {
                return random8bitNumber(start, 256);
            }
        }
        if (start == end) {
            return start;
        } else {
            return random.nextInt(end - start) + start;
        }
    }
}
```

A.13 Package captchabuilder.util.enums

Listing A.14: captchabuilder.util.ImageUtil

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
```

```
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util;

import java.awt.Color;
import java.awt.Graphics2D;
import java.awt.Image;
import java.awt.Toolkit;
import java.awt.image.BufferedImage;
import java.awt.image.FilteredImageSource;
import java.awt.image.ImageFilter;

/**
 * ImageUtil.java (UTF-8)
 *
 * Uitl class for image operations
 *
 * 2013/04/15
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.6
 * @version 1.0.8
 */
public class ImageUtil {

    /**
     * applies a filter to an image
     *
     * @param img the image
     * @param filter the filter
     */
    public static final void applyFilter(BufferedImage img, ImageFilter
        filter) {
        FilteredImageSource src = new FilteredImageSource(img.getSource(),
            filter);
        Image fImg = Toolkit.getDefaultToolkit().createImage(src);
        Graphics2D g = img.createGraphics();
        g.drawImage(fImg, 0, 0, null, null);
        g.dispose();
    }

    /**
     * converts colour format
     *
```

```
     * @param r a colour's red value
     * @param g a colour's green value
     * @param b a colour's blue value
     * @param a a colour's alpha value
     * @return the colour in MSAccess format
     */
    public static final int rgbaToMsAcces(int r, int g, int b, int a) {
         Color c = new Color(r, g, b, a);
        return c.getRGB();
    }

    /**
     * converts colour format
     *
     * @param r a colour's red value
     * @param g a colour's green value
     * @param b a colour's blue value
     * @return the colour in MSAccess format
     */
    public static final int rgbToMsAcces(int r, int g, int b) {
        return rgbaToMsAcces(r, g, b, 0);
    }

    /**
     * converts colour format
     *
     * @param code @return the colour in MSAccess format
     * @return an array containing the RGBa values
     */
    public static final int[] msAccesToRGBa(int code) {
        Color c = new Color(code);
        return colorToRGBa(c);
    }

    /**
     * converts colour format
     *
     * @param hex @return the colour in hexadecimal format
     * @return an array containing the RGBa values
     */
    public static int[] hexadecimalToRGBa(String hex) {
        Color c = Color.decode(hex);
        return colorToRGBa(c);
    }

    private static int[] colorToRGBa(Color c) {
        int[] rgba = new int[4];

        rgba[0] = c.getRed();
        rgba[1] = c.getGreen();
        rgba[2] = c.getBlue();
        rgba[3] = c.getAlpha();

        return rgba;
    }
}
```

Listing A.15: captchacleanup.image.ImageToArray

```
/*
 * The MIT License
```

```
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchacleanup.image;

import java.awt.image.BufferedImage;

/**
 * ImageToArray.java (UTF-8)
 *
 * Utility class images
 *
 * 2013/05/20
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.0.0
 */
public class ImageToArray {

    /**
     * extracts the image data, all pixels within the colour range return
         true
     *
     * @param image the image to be analysed
     * @param startRange the start colour in MSA format
     * @param endRange the end colour in MSA format
     * @return an array with the boolean data
     */
    public static boolean[][] colorRangeToBooleanArray(BufferedImage image,
        int startRange, int endRange) {
        boolean[][] array = new boolean[image.getWidth()][image.getHeight()
            ];
        int startR = (startRange >> 16) & 0x000000FF;
        int startG = (startRange >> 8) & 0x000000FF;
```

```
        int startB = (startRange) & 0x000000FF;
        int endR = (endRange >> 16) & 0x000000FF;
        int endG = (endRange >> 8) & 0x000000FF;
        int endB = (endRange) & 0x000000FF;

        for (int y = 0; y < image.getHeight(); y++) {
            for (int x = 0; x < image.getWidth(); x++) {
                int RGB = image.getRGB(x, y);
                int alpha = (RGB >> 24) & 0x000000FF;
                boolean inRange = false;
                if (alpha != 0) {
                    int R = (startRange >> 16) & 0x000000FF;
                    int G = (startRange >> 8) & 0x000000FF;
                    int B = (startRange) & 0x000000FF;
                    if (startR <= R && R <= endR && startG <= G && G <= endG
                            && startB <= B && B <= endB) {
                        inRange = true;
                    }
                }
                array[x][y] = inRange;
            }
        }
        return array;

    }

    /**
     * extracts the image data, all pixels within the colour range return 1,
          the
     * others return 0
     *
     * @param image the image to be analysed
     * @param startRange the start colour in MSA format
     * @param endRange the end colour in MSA format
     * @return an array with the double data
     */
    public static double[][] colorRangeToDoubleArray(BufferedImage image,
        int startRange, int endRange) {
        double[][] array = new double[image.getWidth()][image.getHeight()];
        int startR = (startRange >> 16) & 0x000000FF;
        int startG = (startRange >> 8) & 0x000000FF;
        int startB = (startRange) & 0x000000FF;
        int endR = (endRange >> 16) & 0x000000FF;
        int endG = (endRange >> 8) & 0x000000FF;
        int endB = (endRange) & 0x000000FF;

        for (int y = 0; y < image.getHeight(); y++) {
            for (int x = 0; x < image.getWidth(); x++) {
                int RGB = image.getRGB(x, y);
                int alpha = (RGB >> 24) & 0x000000FF;
                if (alpha != 0) {
                    int R = (startRange >> 16) & 0x000000FF;
                    int G = (startRange >> 8) & 0x000000FF;
                    int B = (startRange) & 0x000000FF;
                    if (startR <= R && R <= endR && startG <= G && G <= endG
                            && startB <= B && B <= endB) {
                        array[x][y] = 1;
                    } else {
                        array[x][y] = 0;
                    }
                }
            }
```

```
        }
        return array;
    }
}
```

Listing A.16: captchacleanup.image.ImageUtils

```
/*
 * The MIT License
 *
 * Copyright 2013 piva.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchacleanup.image;

import java.awt.Color;
import java.awt.Graphics2D;
import java.awt.Image;
import java.awt.Toolkit;
import java.awt.image.BufferedImage;
import java.awt.image.FilteredImageSource;
import java.awt.image.ImageFilter;
import java.awt.image.ImageProducer;
import java.awt.image.RGBImageFilter;

/**
 * DomainFacade.java (UTF-8)
 *
 * This class will be used a container for static access methods
    manipulating images
 *
 * 2013/04/23
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
```

```
 * @version 1.0.0
 */
public class ImageUtils {

    /**
     * sets a colour to transparent
     *
     * @param bufImage the image
     * @param cString the colour to set transparent
     * @return the image with colour set to transparent
     */
    public static BufferedImage setColorTransparent(BufferedImage bufImage,
        String cString) {
        Color c = Color.decode(cString);
        return setColorRangeTransparent(bufImage, c, c);
    }

    /**
     * sets a colour to transparent
     *
     * @param bufImage the image
     * @param cInt the colour to set transparent in MSA format
     * @return the image with colour set to transparent
     */
    public static BufferedImage setColorTransparent(BufferedImage bufImage,
        int cInt) {
        Color c= new Color(cInt);
        return setColorRangeTransparent(bufImage, c, c);
    }

    /**
     * sets a colour to transparent
     *
     * @param bufImage the image
     * @param c1 the colour to set transparent
     * @param c2 the colour to set transparent
     * @return the image with colour set to transparent
     */
    public static BufferedImage setColorRangeTransparent(BufferedImage
        bufImage, String c1, String c2) {
        return setColorRangeTransparent(bufImage, Color.decode(c1), Color.
            decode(c2));
    }

    /**
     * sets a colour to transparent
     *
     * @param bufImage the image
     * @param c1 the start colour to set transparent in MSA format
     * @param c2 the end colour to set transparent in MSA format
     * @return the image with colour set to transparent
     */
    public static BufferedImage setColorRangeTransparent(BufferedImage
        bufImage, int c1, int c2) {
        return setColorRangeTransparent(bufImage, new Color(c1), new Color(
            c2));
    }

    /**
     * sets a colour to transparent
     *
     * @param bufImage the image
```

```
     * @param c1 the colour to set transparent
     * @param c2 the colour to set transparent
     * @return the image with colour set to transparent
     */
    public static BufferedImage setColorRangeTransparent(BufferedImage
        bufImage, Color c1, Color c2) {
        // Primitive test, just an example
        final int r1 = c1.getRed();
        final int g1 = c1.getGreen();
        final int b1 = c1.getBlue();
        final int r2 = c2.getRed();
        final int g2 = c2.getGreen();
        final int b2 = c2.getBlue();
        ImageFilter filter = new RGBImageFilter() {
            @Override
            public final int filterRGB(int x, int y, int rgb) {
                Color c = new Color(rgb);
                int r = c.getRed();
                int g = c.getGreen();
                int b = c.getBlue();
                if (r >= r1 && r <= r2 && g >= g1 && g <= g2 && b >= b1 && b
                    <= b2) {
                    // Set fully transparent but keep color
                    return rgb & 0xFFFFFF;
                }
                return rgb;
            }
        };

        ImageProducer ip = new FilteredImageSource(bufImage.getSource(),
            filter);
        Image image = Toolkit.getDefaultToolkit().createImage(ip);

        bufImage = new BufferedImage(bufImage.getWidth(), bufImage.getHeight
            (), BufferedImage.TYPE_INT_ARGB);
        Graphics2D g = bufImage.createGraphics();
        g.drawImage(image, 0, 0, null);
        g.dispose();
        return bufImage;
    }
}
```

Listing A.17: captchacleanup.textfromimage.GetImageText

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
```

```
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchacleanup.
    textfromimage;

import java.awt.image.BufferedImage;
import java.util.LinkedList;

/**
 * GetImageText.java (UTF-8)
 *
 * draws boxes around text on an image
 *
 * 2013/05/20
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.0.0
 */
public class GetImageText {

    private BufferedImage image;

    /**
     * Default constructor
     *
     * @param img The image containing text
     */
    public GetImageText(BufferedImage img) {
        image = img;
        merge_densityFactor = 0.5;
        merge_mass = 15;
        merge_dist1 = 4;
        merge_distfac = 1;
        merge_dist2 = 20;
    }

    /**
     * Constructor for testing purposes
     */
    public GetImageText(BufferedImage img, double m_densityFactor,
            int m_mass, int m_dist1, double m_distfac,
            int m_dist2) {
        image = img;
        merge_densityFactor = m_densityFactor;
        merge_mass = m_mass;
        merge_dist1 = m_dist1;
        merge_distfac = m_distfac;
        merge_dist2 = m_dist2;
```

```
    }

    /**
     * Only for debugging - prints out the current parameters
     */
    public void print() {
        System.out.println("m_densityFactor = " + merge_densityFactor);
        System.out.println("m_mass = " + merge_mass);
        System.out.println("m_dist1 = " + merge_dist1);
        System.out.println("m_distfac = " + merge_distfac);
        System.out.println("m_dist2 = " + merge_dist2);
    }

    int red(int rgb) {
        return (rgb & 0xff0000) >> 16;
    }

    int green(int rgb) {
        return (rgb & 0x00ff00) >> 8;
    }

    int blue(int rgb) {
        return rgb & 0xff;
    }

    int rgb(int red, int green, int blue) {
        return blue + (green << 8) + (red << 16);
    }

    /**
     * Discard boxes that do not appear to contain text
     */
    LinkedList discardNonText(LinkedList boxes, int[][] contrast) {
        int i = 0;
        while (i < boxes.size()) {
            int numberOfStems = 0;
            TextRegion thisBox = (TextRegion) boxes.get(i);
            // Count the stems in this box
            if (thisBox.y1 != thisBox.y2) {
                for (int a = thisBox.x1 + 1; a < thisBox.x2 - 1; a++) {
                    int thisStemHeight = 0;
                    for (int b = thisBox.y1 + 1; b < thisBox.y2 - 1; b++) {
                        if ((contrast[a][b] != 0
                                || contrast[a - 1][b] != 0
                                || contrast[a + 1][b] != 0)
                               && (contrast[a][b - 1] != 0
                                || contrast[a - 1][b - 1] != 0
                                || contrast[a + 1][b - 1] != 0)
                               && (contrast[a][b + 1] != 0
                                || contrast[a - 1][b + 1] != 0
                                || contrast[a + 1][b + 1] != 0)) {
                            thisStemHeight++;
                        }
                    }
                    //a stem must cover at least 70% of a vertical line
                    if ((100 * thisStemHeight) / thisBox.height() > 70) {
                        numberOfStems++;
                    }
                }
            }
            if (thisBox.area() < 50
                    || thisBox.aspect() > .2
```

```
                || thisBox.height() < 5
                || thisBox.width() < 20
                // expect at least one stem for every <height> of <width
                    >
                || numberOfStems < thisBox.width() / thisBox.height()) {
            boxes.remove(i--);
        }
        i++;
    }
    return (boxes);
}

/**
 * Shrink each box as much as possible
 */
LinkedList shrink(LinkedList boxes, int[][] contrast) {
    int i = 0;
    while (i < boxes.size()) {
        TextRegion thisBox = (TextRegion) boxes.get(i);
        if (thisBox.x1 != thisBox.x2
                && thisBox.y1 != thisBox.y2) {
            int total = 0;
            for (int a = thisBox.x1; a < thisBox.x2; a++) {
                for (int b = thisBox.y1; b < thisBox.y2; b++) {
                    total += contrast[a][b];
                }
            }
            double averagex = total / thisBox.height();
            double averagey = total / thisBox.width();
            int newx1 = thisBox.x1;
            int newx2 = thisBox.x2;
            int newy1 = thisBox.y1;
            int newy2 = thisBox.y2;
            boolean moved = true;
            while (newx1 < newx2 && moved) {
                moved = false;
                int t1 = 0, t2 = 0;
                for (int b = thisBox.y1; b < thisBox.y2; b++) {
                    t1 += contrast[newx1][b];
                    t2 += contrast[newx2][b];
                }
                if (t1 < averagey) {
                    newx1++;
                    moved = true;
                }
                if (t2 < averagey) {
                    newx2--;
                    moved = true;
                }
            }
            moved = true;
            while (newy1 < newy2 && moved) {
                moved = false;
                int t1 = 0, t2 = 0;
                for (int a = thisBox.x1; a < thisBox.x2; a++) {
                    t1 += contrast[a][newy1];
                    t2 += contrast[a][newy2];
                }
                if (t1 < averagex) {
                    newy1++;
                    moved = true;
                }
```

```
                if (t2 < averagex) {
                    newy2--;
                    moved = true;
                }
            }
            thisBox.x1 = newx1;
            thisBox.x2 = newx2;
            thisBox.y1 = newy1;
            thisBox.y2 = newy2;
        }
        i++;
    }
    return (boxes);
}
public double merge_densityFactor;
public int merge_mass;
public int merge_dist1;
public double merge_distfac;
public int merge_dist2;

LinkedList merge(LinkedList boxes) {
    boolean change = true;
    while (change == true) {
        change = false;
        int i = 0;
        while (i < boxes.size()) {
            int j = 0;
            while (i < boxes.size() && j < boxes.size()) {
                if (i != j) {
                    TextRegion thisBox = (TextRegion) boxes.get(i);
                    TextRegion thatBox = (TextRegion) boxes.get(j);
                    change = merge(thisBox, thatBox);
                    if (change) {
                        boxes.set(i, thisBox);
                        boxes.remove(j);
                        j--;
                    }
                }
                j++;
            }
            i++;
        }
    }
    return (boxes);
}

boolean merge(TextRegion thisBox, TextRegion thatBox) {
    int mergex1 = Math.min(thisBox.x1, thatBox.x1);
    int mergex2 = Math.max(thisBox.x2, thatBox.x2);
    int mergey1 = Math.min(thisBox.y1, thatBox.y1);
    int mergey2 = Math.max(thisBox.y2, thatBox.y2);
    double mergemass = thisBox.mass + thatBox.mass;
    double mergedensity = mergemass
            / ((mergex2 - mergex1) * (mergey2 - mergey1));
    double mergeaspect = ((double) mergey2 - mergey1) / ((double)
        mergex2 - mergex1);

    double reasonsToMerge = 0;
    if (mergedensity > merge_densityFactor * thisBox.density()) {
        reasonsToMerge++;
    }
    if (mergedensity > merge_densityFactor * thatBox.density()) {
```

```
            reasonsToMerge++;
        }
        if (mergeaspect < thisBox.aspect()) {
            reasonsToMerge++;
        }
        if (mergeaspect < thatBox.aspect()) {
            reasonsToMerge++;
        }
        if (thisBox.mass > merge_mass && thatBox.mass > merge_mass) {
            reasonsToMerge++;
        }
        int maxboxwidth = Math.max(thisBox.width(), thatBox.width());
        if (Math.abs(thisBox.y1 - thatBox.y1) < merge_dist1
                && Math.abs(thisBox.y2 - thatBox.y1) < merge_dist1
                && (Math.abs(thisBox.x1 - thatBox.x2) < merge_distfac *
                    maxboxwidth
                || Math.abs(thisBox.x2 - thatBox.x1)
                < merge_distfac * maxboxwidth)) {
            reasonsToMerge++;
        }
        if ((Math.abs(thisBox.y1 - thatBox.y1) < merge_dist2
                || Math.abs(thisBox.y2 - thatBox.y2) < merge_dist2)
                && (Math.abs(thisBox.x1 - thatBox.x2) < merge_distfac *
                    maxboxwidth
                || Math.abs(thisBox.x2 - thatBox.x1)
                < merge_distfac * maxboxwidth)) {
            reasonsToMerge++;
        }
        if (reasonsToMerge > 3) { // 7 reasons max
            thisBox.x1 = mergex1;
            thisBox.x2 = mergex2;
            thisBox.y1 = mergey1;
            thisBox.y2 = mergey2;
            thisBox.mass = mergemass;
            return true;
        }
        return false;
    }

    int[][] getContrast() {
        // Find pixels that stand out from the background
        int[][] contrast = new int[image.getWidth()][image.getHeight()];
        int[][] temp = new int[image.getWidth()][image.getHeight()];
        for (int i = 2; i < image.getWidth() - 2; i++) {
            for (int j = 2; j < image.getHeight() - 2; j++) {
                int thisPixel = image.getRGB(i, j);
                int left = image.getRGB(i - 1, j);
                int left2 = image.getRGB(i - 2, j);
                int right = image.getRGB(i + 1, j);
                int right2 = image.getRGB(i + 2, j);
                int up = image.getRGB(i, j - 1);
                int down = image.getRGB(i, j + 1);
                int t1 = 60; // thresholds
                int t2 = 80;
                if (Math.abs(blue(thisPixel) - blue(right)) > t1
                        || Math.abs(blue(thisPixel) - blue(left)) > t1
                        || Math.abs(blue(thisPixel) - blue(down)) > t1
                        || Math.abs(blue(thisPixel) - blue(up)) > t1
                        || Math.abs(blue(thisPixel) - blue(right2)) > t2
                        || Math.abs(blue(thisPixel) - blue(left2)) > t2
                        || Math.abs(green(thisPixel) - green(right)) > t1
                        || Math.abs(green(thisPixel) - green(left)) > t1
```

```
                    || Math.abs(green(thisPixel) - green(down)) > t1
                    || Math.abs(green(thisPixel) - green(up)) > t1
                    || Math.abs(green(thisPixel) - green(right2)) > t2
                    || Math.abs(green(thisPixel) - green(left2)) > t2
                    || Math.abs(red(thisPixel) - red(right)) > t1
                    || Math.abs(red(thisPixel) - red(left)) > t1
                    || Math.abs(red(thisPixel) - red(down)) > t1
                    || Math.abs(red(thisPixel) - red(up)) > t1
                    || Math.abs(red(thisPixel) - red(right2)) > t2
                    || Math.abs(red(thisPixel) - red(left2)) > t2) {
                temp[i][j] = 1;
            }
        }
    }
    // Look for areas of contrast that extend vertically and
        horizontally
    // but not too far, to eliminate long straight lines (e.g. borders)
    for (int j = 2; j < image.getHeight() - 2; j++) {
        for (int i = 2; i < image.getWidth() - 2; i++) {
            if (temp[i][j] == 1) {
                int width = 0;
                int height = 0;
                for (int k = 0;
                        i + k < image.getWidth() - 2
                        && i - k > 2
                        && (temp[i + k][j] == 1 || temp[i - k][j] == 1)
                        && width++ < 100;
                        k++)
                    ;
                for (int k = 0;
                        j + k < image.getHeight() - 2
                        && j - k > 2
                        && (temp[i][j + k] == 1 || temp[i][j - k] == 1)
                        && height++ < 100;
                        k++)
                    ;
                int totalOnLine = 0;
                for (int k = Math.max(2, i - 40);
                        k < Math.min(image.getWidth() - 2, i + 40);
                        k++) {
                    totalOnLine += temp[k][j];
                }
                if (totalOnLine > 7 && width < 100 && height < 100) {
                    contrast[i][j] = 1;
                }
            }
        }
    }
    return contrast;
}

/**
 * Looks for areas of text in an image.
 *
 * @return a LinkedList of boxes that are likely to contain text.
 */
public LinkedList getTextBoxes() {
    LinkedList boxes = new LinkedList();

    int[][] contrast = getContrast();

    try {
```

```
            BufferedImage contrastpng = new BufferedImage(image.getWidth(),
                image.getHeight(), BufferedImage.TYPE_INT_RGB);
            for (int i = 0; i < image.getWidth(); i++) {
                for (int j = 0; j < image.getHeight(); j++) {
                    contrastpng.setRGB(i, j, 0xffffff * contrast[i][j]);
                }
            }
        } catch (Exception e) {
            System.out.println("Exception: " + e);
        }

        int contrastOnLine[] = new int[image.getHeight()];
        for (int j = 1; j < image.getHeight() - 1; j++) {
            int count = 0;
            contrastOnLine[j] = 0;
            for (int a = 0; a < image.getWidth(); a++) {
                count += contrast[a][j];
                contrastOnLine[j] += contrast[a][j];
            }
        }
        for (int j = 1; j < image.getHeight() - 1; j++) {
            contrastOnLine[j] = (contrastOnLine[j - 1]
                    + contrastOnLine[j]
                    + contrastOnLine[j + 1]) / 3;
        }
        for (int j = 1; j < image.getHeight() - 1; j++) {
            contrastOnLine[j] = (contrastOnLine[j - 1]
                    + contrastOnLine[j]
                    + contrastOnLine[j + 1]) / 3;
        }
        int averageOnLine = 0;
        for (int j = 1; j < image.getHeight() - 1; j++) {
            averageOnLine += contrastOnLine[j];
        }
        averageOnLine /= (image.getHeight() - 2);
        boolean intext = false;
        int boxstart = 0;
        int boxaverage = 0;
        int boxlines = 0;
        for (int j = 1; j < image.getHeight() - 1; j++) {
            if (contrastOnLine[j] > averageOnLine && !intext) {
                intext = true;
                boxstart = j;
                boxaverage = contrastOnLine[j];
                boxlines = 1;
            } else if (contrastOnLine[j] > averageOnLine) {
                boxaverage += contrastOnLine[j];
                boxlines++;
            } else if (contrastOnLine[j] <= averageOnLine && intext) {
                // found vertical limits, now find horizontal.
                intext = false;
                int boxend = j;
                if (boxend - boxstart > 10) {
                    // text must be higher than 10 pixels
                    boxaverage /= boxlines;
                    int contrastOnColumn[] = new int[image.getWidth()];
                    for (int i = 1; i < image.getWidth() - 1; i++) {
                        for (int b = boxstart; b < boxend; b++) {
                            contrastOnColumn[i] += contrast[i][b];
                        }
                    }
                    for (int i = 1; i < image.getWidth() - 1; i++) {
```

```
                    contrastOnColumn[i] = (contrastOnColumn[i - 1]
                            + contrastOnColumn[i]
                            + contrastOnColumn[i + 1]) / 3;
                }
                for (int i = 1; i < image.getWidth() - 1; i++) {
                    contrastOnColumn[i] = (contrastOnColumn[i - 1]
                            + contrastOnColumn[i]
                            + contrastOnColumn[i + 1]) / 3;
                }
                int averageOnColumn = 0;
                for (int i = 1; i < image.getWidth() - 1; i++) {
                    averageOnColumn += contrastOnColumn[i];
                }
                averageOnColumn /= (image.getWidth() - 2);
                boolean intextx = false;
                int boxstartx = 0;
                for (int i = 1; i < image.getWidth() - 1; i++) {
                    if (contrastOnColumn[i] > averageOnColumn / 2
                            && !intextx) {
                        intextx = true;
                        boxstartx = i;
                    } else if (contrastOnColumn[i] <= averageOnColumn /
                        2
                            && intextx) {
                        intextx = false;
                        int boxendx = i;
                        // found horizontal limits,
                        // now (if necessary) shrink
                        // vertical limits
                        int newcount = 0;
                        int tempboxstart = boxstart;
                        int tempboxend = boxend;
                        while (tempboxstart < boxend
                                && newcount == 0) {
                            for (int a = boxstartx; a < boxendx; a++) {
                                newcount += contrast[a][tempboxstart];
                            }
                            if (newcount < 2) {
                                tempboxstart++;
                            }
                        }
                        newcount = 0;
                        while (tempboxstart < boxend && newcount == 0) {
                            for (int a = boxstartx; a < boxendx; a++) {
                                newcount += contrast[a][tempboxend];
                            }
                            if (newcount < 2) {
                                tempboxend--;
                            }
                        }
                        TextRegion thisBox = new TextRegion(boxstartx,
                                tempboxstart,
                                boxendx,
                                tempboxend,
                                image.getWidth(),
                                image.getHeight(),
                                boxaverage);
                        boxes.add(thisBox);
                    }
                }
            }
        }
```

```
        }

        System.out.println(boxes.size() + " bounding boxes");
        shrink(boxes, contrast);
        boxes = merge(boxes);
        //shrink(boxes, contrast);
        System.out.println(boxes.size() + " bounding boxes after merge");
        boxes = discardNonText(boxes, contrast);
        System.out.println(boxes.size() + " bounding boxes after delete");
        return (shrink(boxes, contrast));
    }

    /**
     * Isolate text
     *
     * @return a <code>BufferedImage</code> value
     */
    public BufferedImage isolateText(LinkedList boxes) {
        BufferedImage outputimage = new BufferedImage(image.getWidth(),
                image.getHeight(),
                BufferedImage.TYPE_INT_RGB);
        // make everything monochrome
        for (int a = 0; a < image.getWidth(); a++) {
            for (int b = 0; b < image.getHeight(); b++) {
                int colour = image.getRGB(a, b);
                int average = (red(colour) + green(colour) + blue(colour)) /
                     3;
                outputimage.setRGB(a, b, rgb(average, average, average));
            }
        }
        // fill text boxes with colour
        for (int i = 0; i < boxes.size(); i++) {
            TextRegion thisBox = (TextRegion) boxes.get(i);
            int x1 = Math.max(1, thisBox.x1);
            int x2 = Math.min(image.getWidth() - 2, thisBox.x2);
            int y1 = Math.max(1, thisBox.y1);
            int y2 = Math.min(image.getHeight() - 2, thisBox.y2);
            for (int a = x1; a < x2; a++) {
                for (int b = y1; b < y2; b++) {
                    outputimage.setRGB(a, b, image.getRGB(a, b));
                }
            }
        }
        // draw red border around each text box
        int RED = 0xff0000;
        for (int i = 0; i < boxes.size(); i++) {
            TextRegion thisBox = (TextRegion) boxes.get(i);
            int x1 = Math.max(1, thisBox.x1);
            int x2 = Math.min(image.getWidth() - 2, thisBox.x2);
            int y1 = Math.max(1, thisBox.y1);
            int y2 = Math.min(image.getHeight() - 2, thisBox.y2);
            for (int a = x1; a < x2; a++) {
                outputimage.setRGB(a, thisBox.y1, RED);
                outputimage.setRGB(a, thisBox.y2, RED);
            }
            for (int a = y1; a < y2; a++) {
                outputimage.setRGB(thisBox.x1, a, RED);
                outputimage.setRGB(thisBox.x2, a, RED);
            }
        }
        return (outputimage);
    }
```

```
}
```

Listing A.18: captchacleanup.textfromimage.TextRegion

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchacleanup.
    textfromimage;

/**
 * TextRegion.java (UTF-8)
 *
 * generates a text area
 *
 * 2013/05/20
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.0.0
 */
public class TextRegion {
    int x1;
    int y1;
    int x2;
    int y2;
    double mass;

    /**
     * Creates a new <code>TextRegion</code> instance.
     *
     * @param xs the start x coordinate
```

```
     * @param ys the start y coordinate
     * @param xe the end x coordinate
     * @param ye the end y coordinate
     * @param maxx the max x coordinate
     * @param maxy the max y coordinate
     */
    public TextRegion(int xs, int ys, int xe, int ye, int maxx, int maxy,
        double m) {
        if (xs < 0)
            x1 = 0;
        else if (xs > maxx)
            x1 = maxx;
        else x1 = xs;
        if (xe < 0)
            x2 = 0;
        else if (xe > maxx)
            x2 = maxx;
        else x2 = xe;
        if (ys < 0)
            y1 = 0;
        else if (ys > maxy)
            y1 = maxy;
        else y1 = ys;
        if (ye < 0)
            y2 = 0;
        else if (ye > maxy)
            y2 = maxy;
        else y2 = ye;
        mass = m;
    }

    int area() {
        return width() * height();
    }

    int height() {
        return y2 - y1;
    }

    int width() {
        return x2 - x1;
    }

    double density() {
        return mass / area();
    }

    double aspect() {
        return (double)height() / (double)width();
    }
}
```

A.14 Package neuralnetworks.network.encog

Listing A.19: neuralnetworks.network.NeuralNetworkActions

```
/*
```

```
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network;

/**
 * NeuralNetworkActions.java (UTF-8)
 *
 * Interface that defines the actions all NeuralNetworks should implement
 *
 * 2013/05/20
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.0.0
 */
public interface NeuralNetworkActions {

    /**
     * Build/generates the network.
     */
    public void buildNetwork();

    /**
     * Trains the network
     */
    public void trainNetwork();

    /**
     * evaluates the input with the network.
     *
     * @param input the object to be evaluated
     * @param maxIterations the maximum iterations before giving up
     * @return the result
```

```
     */
    public double[] evaluate(double[] input, int maxIterations);
}
```

Listing A.20: neuralnetworks.network.NeuralNetwork

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network;

import java.io.Serializable;

/**
 * NeuralNetwork.java (UTF-8)
 *
 * Abstract class that all neural networks should extend, this is to
     streamline
 * the testing and building statics phase. The actions of the networks are
 * defined by NeuralNetworkActions interface implements serialisable for
     saving
 * the networks.
 *
 * 2013/05/19
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.1.2
 * @see NeuralNetworkActions
 */
public abstract class NeuralNetwork implements NeuralNetworkActions,
    Serializable {
```

```
    private int id, hSize, vSize;

    /**
     * Default constructor, sets the id to -1, hSize to 40 and vSize to 50.
     *
     */
    public NeuralNetwork() {
        this(-1, 40, 50);
    }

    /**
     * Constructor
     *
     * @param id the id of the network
     * @param hSize the horizontal size (width)
     * @param vSize the vertical size (height)
     */
    public NeuralNetwork(int id, int hSize, int vSize) {
        this.id = id;
        this.hSize = hSize;
        this.vSize = vSize;
    }

    public int getId() {
        return id;
    }

    public void setId(int id) {
        this.id = id;
    }

    public int getHsize() {
        return hSize;
    }

    public void setHsize(int hSize) {
        this.hSize = hSize;
    }

    public int getVsize() {
        return vSize;
    }

    public void setVsize(int vSize) {
        this.vSize = vSize;
    }

    /**
     * generates a string representation of the layers layout
     * @return a string representation of the layers layout
     */
    public abstract String getLayerLayout();
}
```

Listing A.21: neuralnetworks.util.CharacterPatternUtils

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
```

```
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.util;

import java.util.Arrays;

/**
 * CharacterPatternUtils.java (UTF-8)
 *
 * Utility class for operations concerning network training and testing.
 *
 * 2013/05/20
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.0.0
 */
public class CharacterPatternUtils {

    /**
     * converts a character to an array of doubles, each double in the array
     * represents a bit from the byte defining the character
     *
     * @param c the character
     * @return an array of doubles representing the char
     */
    public static double[] characterToBitArray(char c) {
        String bitString = Integer.toBinaryString((int) c);
        System.err.println(c + " bitstring: " + bitString);

        // leftpad the string with 0 so it is atleast 8 bit long;
        while (bitString.length() < 8) {
            bitString = "0" + bitString;
        }

        double bit = 0;
```

```
        double[] result = new double[8];
        int resultIndex = 7;

        for (int i = result.length - 1; i > 0; i--) {
            if (bitString.charAt(i) == '1') {
                bit = 1;
            } else {
                bit = 0;
            }
            result[resultIndex--] = bit;
        }

        System.err.println(c + " bitArray: " + Arrays.toString(result));
        return result;
    }
}
```

Listing A.22: neuralnetworks.util.EncogTrainingSet

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.util;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text.AbstractWordRenderer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text.DefaultWordRenderer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text.WordRenderer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
```

```
import java.awt.Graphics2D;
import java.awt.RenderingHints;
import java.awt.image.BufferedImage;
import java.io.File;
import java.io.IOException;
import javax.imageio.ImageIO;

/**
 * EncogTrainingSet.java (UTF-8)
 *
 * Utility class to help generate the input and output trainingsets for an
    encog
 * Neural Network.
 *
 * 2013/05/20
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.0.0
 */
public class EncogTrainingSet {

    /**
     * builds the input set from a collection of chars
     *
     * @param chars the collection of chars to train for
     * @param hSize the width of the char image
     * @param vSize the height of the char image
     * @return
     */
    public static double[][] buildTrainingInputSet(char[] chars, int hSize,
        int vSize) {
        double[][] inputTrainingsSet = new double[chars.length][];
        System.out.println("building Trainingsets");
        BufferedImage img;
        WordRenderer renderer = new DefaultWordRenderer(new ColorRangeRGBA
            (0, 0, 0, 255), AbstractWordRenderer.DEFAULT_FONTS, 0, 0.25,
            CaptchaConstants.DEFAULT_STROKE_WIDTH);
        int index = 0;

        for (char c : chars) {
            img = new BufferedImage(40, 50, BufferedImage.TYPE_INT_ARGB);
            renderer.render(String.valueOf(c), img);

            // check if size == the default size (40*50) if not scale
            if (hSize != 40 || vSize != 50) {
                BufferedImage resized = new BufferedImage(hSize, vSize, img.
                    getType());
                Graphics2D g = resized.createGraphics();
                g.setRenderingHint(RenderingHints.KEY_INTERPOLATION,
                    RenderingHints.VALUE_INTERPOLATION_BILINEAR);
                g.drawImage(img, 0, 0, hSize, vSize, 0, 0, img.getWidth(),
                    img.getHeight(), null);
                g.dispose();

                //replace the origal with the resized
                img = resized;
            }

            try {
```

```
                String path = "TrainingsetImages/";
                // if the directory does not exist, create it and it's
                    parents
                File theDir = new File(path);
                if (!theDir.exists()) {
                    System.out.println("creating␣directory:␣" + path);
                    boolean result = theDir.mkdirs();
                    if (result) {
                        System.out.println("Directory␣created");
                    }
                }

                ImageIO.write(img, "png", new File(path + Character.getName(
                    c) + "-" + hSize + "X" + vSize + ".png"));
            } catch (IOException ex) {
                System.err.println(ex.getMessage());
            }

            inputTrainingsSet[index++] = ImageToInputPattern.
                colorRangeToDoubleInputPattern(img, 0, 0);
        }

        return inputTrainingsSet;
    }

    /**
     * builds the ideal response set from a collection of chars
     *
     * @param chars the collection of chars to train for
     * @return
     */
    public static double[][] buildTrainingIdealSet(char[] chars) {
        double[][] outputTrainingsSet = new double[chars.length][];
        System.out.println("building␣TrainingIdealSet");
        int index = 0;

        for (char c : chars) {
            outputTrainingsSet[index++] = CharacterPatternUtils.
                characterToBitArray(c);
        }

        return outputTrainingsSet;
    }
}
```

Listing A.23: neuralnetworks.util.ImageToInputPattern

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
```

```
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.util;

import be.hogent.pietervaneeckhout.bachelorthesis.captchacleanup.image.
    ImageToArray;
import java.awt.image.BufferedImage;
import org.encog.ml.data.specific.BiPolarNeuralData;

/**
 * ImageToInputPattern.java (UTF-8)
 *
 * Utility class to convert an Image to a usable pattern for input to a
     network
 * This will reduce a 2-dimensional image to 1-dimensional array of doubles
 *
 * 2013/05/19
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.0.0
 */
public class ImageToInputPattern {

    /**
     * reduce a 2-dimensional image to 1-dimensional array of doubles based
         on the colour range supplied.
     *
     * @param img the image to be transformed
     * @param startRange the numerical (!NOT HEX) value of the range start (
         inclusive)
     * @param endRange the numerical (!NOT HEX) value of the range end (
         inclusive)
     * @return the neural network input pattern based on the image.
     */
    public static double[] colorRangeToDoubleInputPattern(BufferedImage img,
         int startRange, int endRange) {
        return reduceDimension(ImageToArray.colorRangeToDoubleArray(img,
            startRange, endRange));
    }

    private static double[] reduceDimension(double[][] data) {
        int resultIndex = 0;
        double[] result = new double[data.length * data[0].length];
        for (int y = 0; y < data[0].length; y++) {
            for (int x = 0; x < data.length; x++) {
```

```
                result[resultIndex++] = data[x][y];
            }
        }
        return result;
    }

    /**
     * converts an image into BiPolarNeuralData based on a colour range
     * @param img the image to be transformed
     * @param startRange the start colour range in MSA format
     * @param endRange the end colour range in MSA format
     * @return BiPolarNeuralData
     * @see BiPolarNeuralData
     */
    public static BiPolarNeuralData colorRangeToBiPolarNeuralData(
        BufferedImage img, int startRange, int endRange) {
        return booleanArrayToBiPolarNeuralData(ImageToArray.
            colorRangeToBooleanArray(img, startRange, endRange));
    }

    private static BiPolarNeuralData booleanArrayToBiPolarNeuralData(boolean
        [][] data){
        int resultIndex = 0;
        int width = data.length;
        int height = data[0].length;
        BiPolarNeuralData result = new BiPolarNeuralData(width* height);
        for (int y = 0; y < height; y++) {
            for (int x = 0; x < width; x++) {
                result.setData(resultIndex++, data[x][y]);
            }
        }
        return result;
    }
}
```

A.15 Package captchabuilder.elementcreator.producer.backgrou

A.16 Package captchabuilder.elementcreator.producer.border

A.17 Package captchabuilder.elementcreator.producer.noise

A.18 Package captchabuilder.elementcreator.producer.text

A.19 Package captchabuilder.elementcreator.renderer.gimpy

A.20 Package captchabuilder.elementcreator.renderer.text

Listing A.24: captchabuilder.util.enums.CaptchaConstants

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums
    ;

import java.security.SecureRandom;
import java.util.Random;

/**
 * CaptchaConstants.java (UTF-8)
 *
 * Class to contain some of the constants
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.7
 * @version 1.0.7
 */
public class CaptchaConstants {

    public static final Random RANDOM = new SecureRandom();
    public static final char[] LETTERS = new char[]{'a', 'b', 'c', 'd', 'e',
        'f', 'g', 'h', 'i', 'j', 'k', 'l', 'm', 'n', 'o', 'p', 'q', 'r', 's
        ', 't', 'u', 'v', 'w', 'x', 'y', 'z'};
    public static final char[] NUMBERS = new char[]{'0', '1', '2', '3', '4',
        '5', '6', '7', '8', '9'};
    public static final char[] SPECIAL = new char[]{'&', '!', '@', '?', '#',
        '$', '%', '+', '='};
    public static final char[] REDUCEDALPHANUMERIC = new char[]{'a', 'b', 'c
        ', 'd', 'e', 'f', 'g', 'h', 'k', 'm', 'n', 'p', 'r', 'w', 'x', 'y',
        '2', '3', '4', '5', '6', '7', '8',};
```

```
    public static final char[] ARABIC_CHARS = {'\u0627', '\u0628', '\u062a',
         '\u062b', '\u062c', '\u062d', '\u062e', '\u062f', '\u0630', '\u0631
        ', '\u0632', '\u0633', '\u0634', '\u0635', '\u0636', '\u0637', '\
        u0638', '\u0639', '\u063a', '\u0641', '\u0642', '\u0643', '\u0644',
        '\u0645', '\u0646', '\u0647', '\u0648', '\u064a'};
    public static final int DEFAULT_LENGTH = 5;
    public static final double DEFAULT_YOFFSET = 0.25;
    public static final double DEFAULT_XOFFSET = 0.05;
    public static final float DEFAULT_STROKE_WIDTH = 0f;
    public static final String buildSequencelvl1Delim = "[:]+";
    public static final String buildSequencelvl2Delim = "[!]+";
    public static final String buildSequencelvl3Delim = "[#]+";
    public static final String buildSequencelvl4Delim = "[@]+";
    public static final String buildSequencelvl5Delim = "[*]+";
    public static final String buildSequencelvl6Delim = "[.]+";
    public static final String buildSequencelvl7Delim = "[?]+";
}
```

A.21 Package captchabuilder.util.enums.producer

A.22 Package captchabuilder.util.enums.renderer

Listing A.25: neuralnetworks.network.encog.EncogBasicNetworkBuilder

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network.
    encog;
```

```
import be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network.
    encog.util.PropagationType;
import java.util.ArrayList;
import java.util.List;
import org.encog.ml.train.strategy.Strategy;

/**
 * EncogBasicNetworkBuilder.java (UTF-8)
 *
 * Provides a builder for a configurable Encog BasicNetwork
 *
 * 2013/05/19
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.1.0
 */
public class EncogBasicNetworkBuilder {
    private int id;
    private double[][] trainingInput;
    private double[][] trainingIdeal;
    private int[] hiddenLayers;
    private double accuracy;
    private double learningRate;
    private List<Strategy> trainingStrategies;
    private PropagationType propagationType;
    private int hSize;
    private int vSize;

    /**
     * builderConstructor
     *
     * @param trainingInput The inputs for the training
     * @param trainingIdeal the expected results for the training
     */
    public EncogBasicNetworkBuilder(double[][] trainingInput, double[][]
        trainingIdeal) {
        this.id = -1;
        this.accuracy = 0.00000000001;
        this.learningRate = 2;
        this.trainingStrategies = new ArrayList<>();
        this.propagationType = PropagationType.ResilientPropagation;
        this.trainingInput = trainingInput;
        this.trainingIdeal = trainingIdeal;
        this.hSize = 40;
        this.vSize = 50;
    }

    public EncogBasicNetworkBuilder setId(int id) {
        this.id = id;
        return this;
    }

    public EncogBasicNetworkBuilder setHsize(int hSize) {
        this.hSize = hSize;
        return this;
    }

    public EncogBasicNetworkBuilder setVsize(int vSize) {
```

```
        this.vSize = vSize;
        return this;
    }

    public EncogBasicNetworkBuilder setHiddenLayers(int[] hiddenLayers) {
        this.hiddenLayers = hiddenLayers;
        return this;
    }

    public EncogBasicNetworkBuilder setAccuracy(double accuracy) {
        this.accuracy = accuracy;
        return this;
    }

    public EncogBasicNetworkBuilder setLearningRate(double learningRate) {
        this.learningRate = learningRate;
        return this;
    }

    public EncogBasicNetworkBuilder setTrainingStrategies(List<Strategy>
        trainingStrategies) {
        this.trainingStrategies = trainingStrategies;
        return this;
    }

    public EncogBasicNetworkBuilder setPropagationType(PropagationType
        propagationType) {
        this.propagationType = propagationType;
        return this;
    }

    public EncogBasicNetwork createEncogBasicLetterRecognitionNetwork() {
        return new EncogBasicNetwork(id, hSize, vSize, trainingInput,
            trainingIdeal, hiddenLayers, accuracy, learningRate,
            trainingStrategies, propagationType);
    }

}
```

Listing A.26: neuralnetworks.network.encog.EncogBasicNetwork

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
```

```
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network.
    encog;

import be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network.
    encog.util.PropagationType;
import be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network.
    NeuralNetwork;
import static be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.
    network.encog.util.PropagationType.ManhattanPropagation;
import java.util.List;
import org.encog.engine.network.activation.ActivationSigmoid;
import org.encog.ml.data.MLDataSet;
import org.encog.ml.data.basic.BasicMLDataSet;
import org.encog.ml.train.MLTrain;
import org.encog.ml.train.strategy.Strategy;
import org.encog.neural.networks.BasicNetwork;
import org.encog.neural.networks.layers.BasicLayer;
import org.encog.neural.networks.training.propagation.back.Backpropagation;
import org.encog.neural.networks.training.propagation.manhattan.
    ManhattanPropagation;
import org.encog.neural.networks.training.propagation.resilient.
    ResilientPropagation;
import org.encog.neural.networks.training.propagation.scg.
    ScaledConjugateGradient;
import org.encog.util.simple.EncogUtility;

/**
 * EncogBasicNetwork.java (UTF-8)
 *
 * Provides a configurable Encog BasicNetwork
 *
 * 2013/05/19
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.1.0
 */
public class EncogBasicNetwork extends NeuralNetwork {

    private double trainingInput[][];
    private double trainingIdeal[][];
    private BasicNetwork network;
    private int[] hiddenLayers;
    private double accuracy;
    private double learningRate;
    private List<Strategy> trainingStrategies;
    private PropagationType propagationType;

    /**
```

```
     * Constructor
     *
     * @param id the id of the network
     * @param trainingInput The inputs for the training
     * @param trainingIdeal the expected results for the training
     * @param hiddenLayers the amount of neuron each hidden layer has (in
         order)
     * @param acuracy the desired accuracy
     * @param learningRate the learning rate (only used with
     * ManhattanPropagation)
     * @param trainingStrategies the training strategies to be used
     */
    protected EncogBasicNetwork(int id, int hSize, int vSize, double[][]
        trainingInput, double[][] trainingIdeal, int[] hiddenLayers, double
        accuracy, double learningRate, List<Strategy> trainingStrategies,
        PropagationType propagationType) {
        super(id, hSize, vSize);
        this.trainingInput = trainingInput;
        this.trainingIdeal = trainingIdeal;
        this.hiddenLayers = hiddenLayers;
        this.accuracy = accuracy;
        this.learningRate = learningRate;
        this.trainingStrategies = trainingStrategies;
        this.propagationType = propagationType;
    }

    @Override
    public void buildNetwork() {
        System.out.println("Building basic network");
        this.network = new BasicNetwork();

        System.out.println("Adding layers to network");
        network.addLayer(new BasicLayer(null, true, (super.getHsize() *
            super.getVsize())));
        if (hiddenLayers != null) {
            for (int i : hiddenLayers) {
                network.addLayer(new BasicLayer(new ActivationSigmoid(),
                    true, i));
            }
        }
        network.addLayer(new BasicLayer(new ActivationSigmoid(), true,
            trainingIdeal[0].length));

        network.getStructure().finalizeStructure();
        network.reset();
    }

    @Override
    public void trainNetwork() {
        network.reset();

        System.out.println("initializing network training system");
        MLDataSet trainingSet = new BasicMLDataSet(trainingInput,
            trainingIdeal);
        final MLTrain training;

        switch (propagationType) {
            case Backpropagation:
                training = new Backpropagation(network, trainingSet);
                break;
            case ManhattanPropagation:
```

```
            training = new ManhattanPropagation(network, trainingSet,
                learningRate);
            break;
        case ResilientPropagation:
            training = new ResilientPropagation(network, trainingSet);
            break;
        case ScaledConjugateGradient:
            training = new ScaledConjugateGradient(network, trainingSet)
                ;
            break;
        default:
            IllegalArgumentException e = new IllegalArgumentException("
                Unknown propagationType");
            throw e;
    }

    System.out.println("Propagation: " + propagationType.name());

    System.out.println("adding training strategies");

    for (Strategy strategy : trainingStrategies) {
        training.addStrategy(strategy);
    }

    System.out.println("Start training to acuracy: " + accuracy);
    int layers = network.getLayerCount();
    System.out.println("#Layer: " + layers);
    for (int i = 0; i < layers; i++) {
        System.out.println("Layer " + i + " #neurons: " + network.
            getLayerTotalNeuronCount(i));
    }

    long startTimeLong = System.nanoTime();
    EncogUtility.trainToError(training, accuracy);
    long endTimeLong = System.nanoTime();
    double durationInSec = (double) ((endTimeLong - startTimeLong) /
        Math.pow(10, 9));
    System.out.println("Finished training network in: " + durationInSec)
        ;
}

@Override
public double[] evaluate(double[] input, int maxIterations) {
    double[] output = new double[trainingIdeal[0].length];
    System.out.println("Evaluating input");
    long startTimeLong = System.nanoTime();
    network.compute(input, output);
    long endTimeLong = System.nanoTime();
    double durationInSec = (double) ((endTimeLong - startTimeLong) /
        Math.pow(10, 9));
    System.out.println("Finished evaluating in: " + durationInSec);

    return output;
}

@Override
public String getLayerLayout() {
    StringBuilder strBuilder = new StringBuilder();
    strBuilder.append("[ ");
    int layers = network.getLayerCount();
    for (int i = 0; i < layers; i++) {
```

```
            strBuilder.append(network.getLayerTotalNeuronCount(i) - 1).
                append(" ");
        }

        return strBuilder.append("]").toString();
    }
}
```

Listing A.27: neuralnetworks.network.encog.EncogHopfieldNetworkBuilder

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network.
    encog;

/**
 * EncogBasicNetworkBuilder.java (UTF-8)
 *
 * Provides a builder for a configurable Encog HopfieldNetwork
 *
 * 2013/05/19
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.0.0
 */
public class EncogHopfieldNetworkBuilder {

    private double[][] trainingInput;
    private int id;
    private int hSize;
```

```
    private int vSize;

    /**
     * builder constructor
     *
     * @param trainingInput the input data for training
     * @param hSize the width of the network
     * @param vSize the height of the network
     */
    public EncogHopfieldNetworkBuilder(double[][] trainingInput, int hSize,
        int vSize) {
        this.trainingInput = trainingInput;
        this.hSize = hSize;
        this.vSize = vSize;
        this.id = -1;
    }

    public EncogHopfieldNetworkBuilder setId(int id) {
        this.id = id;
        return this;
    }

    public EncogHopfieldNetwork createEncogHopfieldNetwork() {
        return new EncogHopfieldNetwork(trainingInput, id, hSize, vSize);
    }
}
```

Listing A.28: neuralnetworks.network.encog.EncogHopfieldNetwork

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network.
    encog;
```

```
import be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network.
    NeuralNetwork;
import org.encog.ml.data.specific.BiPolarNeuralData;
import org.encog.neural.thermal.HopfieldNetwork;

/**
 * EncogBasicNetwork.java (UTF-8)
 *
 * Provides a configurable Encog HopfieldNetwork
 *
 * 2013/05/19
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.0.0
 */
public class EncogHopfieldNetwork extends NeuralNetwork {
    private double trainingInput[][];
    private HopfieldNetwork network;
    private final int neuroncount;

    /**
     * Constructor
     *
     * @param trainingInput the inputs for training the network
     * @param id the network id
     * @param hSize the horizontal size of the network
     * @param vSize the vertical size of the network
     */
    protected EncogHopfieldNetwork(double[][] trainingInput, int id, int
        hSize, int vSize) {
        super(id, hSize, vSize);
        this.trainingInput = trainingInput;
        neuroncount = vSize*hSize;

        if (neuroncount != trainingInput[0].length) {
            IllegalArgumentException e = new IllegalArgumentException("the␣
                length␣of␣the␣trainingsinputs␣and␣the␣neuroncount␣do␣not␣
                match");
            throw e;
        }
    }

    @Override
    public void buildNetwork() {
        System.out.println("Building␣hopfield␣network");
        network = new HopfieldNetwork(neuroncount);
    }

    @Override
    public void trainNetwork() {
        network.reset();
        System.out.println("Training␣hopfield␣network");
        long startTimeLong = System.nanoTime();
        for (double[] ds : trainingInput) {
            network.addPattern(doubleArrayToBiPolarNeuralData(ds));
        }
        long endTimeLong = System.nanoTime();
```

```
        double durationInSec = (double) ((endTimeLong - startTimeLong) /
            Math.pow(10, 9));
        System.out.println("Finished training network in: " + durationInSec)
            ;
    }

    private BiPolarNeuralData doubleArrayToBiPolarNeuralData(double[] data)
        {
        BiPolarNeuralData patternData = new BiPolarNeuralData(neuroncount);
        if (data.length != neuroncount) {
            IndexOutOfBoundsException e = new IndexOutOfBoundsException("the
                size of the traingsinputs is different from the amount of
                input neurons");
            throw e;
        }
        patternData.setData(data);
        return patternData;
    }

    @Override
    public double[] evaluate(double[] input, int maxIterations) {
        System.out.println("hopfield network evaluating with max iterations:
            " + maxIterations);
        BiPolarNeuralData inputPattern = doubleArrayToBiPolarNeuralData(
            input);
        network.setCurrentState(inputPattern);
        int cycles = network.runUntilStable(maxIterations);
        System.out.println("Cycles until stable(max " + maxIterations + "):
            " + cycles + ", result=");
        BiPolarNeuralData outputPattern = (BiPolarNeuralData) network.
            getCurrentState();
        System.out.println(convertForDisplay(inputPattern, outputPattern));
        return outputPattern.getData();
    }

    private String convertForDisplay(BiPolarNeuralData inputPattern,
        BiPolarNeuralData outputPattern) {
        int index1 = 0;
        int index2 = 0;
        StringBuilder block = new StringBuilder();

        for (int row = 0; row < super.getVsize(); row++) {


            for (int col = 0; col < super.getHsize(); col++) {
                if (inputPattern.getBoolean(index1++)) {
                    block.append('O');
                } else {
                    block.append(' ');
                }
            }

            block.append("   ->   ");

            for (int col = 0; col < super.getHsize(); col++) {
                if (outputPattern.getBoolean(index2++)) {
                    block.append('O');
                } else {
                    block.append(' ');
                }
            }
```

```
            block.append("\n");
        }

        return block.toString();
    }

    @Override
    public String getLayerLayout() {
        return "[ " + getHsize() + " X " + getVsize() + " ]";
    }
}
```

A.23 Package neuralnetworks.network.encog.util

Listing A.29: captchabuilder.elementcreator.producer.background.AbstractBackgroundProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background;


import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import java.awt.image.BufferedImage;

/**
 * AbstractBackgroundProducer.java (UTF-8)
 *
```

```
 * Abstract class template, implementing classes will generate backgrounds.
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.4
 * @version 1.1.0
 */
public abstract class AbstractBackgroundProducer implements
    BackgroundProducer {

    protected ColorRangeRGBA  colorRange1;
    protected ColorRangeRGBA  colorRange2;

    protected AbstractBackgroundProducer(ColorRangeRGBA  colors1Range,
        ColorRangeRGBA  colors2Range) {
        this.colorRange1 = colors1Range;
        this.colorRange2 = colors2Range;
    }

    @Override
    public BufferedImage addBackground(BufferedImage image) {
        return getBackground(image.getWidth(), image.getHeight());
    }
}
```

Listing A.30: captchabuilder.elementcreator.producer.background.BackgroundProducerBuilder

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
```

```
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.CaptchaElementCreatorBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    producer.BackgroundProducerType;


/**
 * BackgroundProducerBuilder.java (UTF-8)
 *
 * Builder for a background producer
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.4
 * @version 1.1.0
 */
public class BackgroundProducerBuilder implements
    CaptchaElementCreatorBuilder {

    private ColorRangeRGBA colorRange1;
    private ColorRangeRGBA colorRange2;
    private BackgroundProducerType type;

    /**
     * Constructor
     *
     * @param type the type of BackgroundProducer to be created
     */
    public BackgroundProducerBuilder(BackgroundProducerType type) {
        this.type = type;

        switch (type) {
            case FLATCOLOR:
                colorRange1 = new ColorRangeRGBA(222, 222, 222);
                colorRange2 = new ColorRangeRGBA(222, 222, 222);
                break;
            case SQUIGGLES:
                colorRange1 = new ColorRangeRGBA(0);
                colorRange2 = new ColorRangeRGBA(0);
                break;
            case TRANSPARENT:
                colorRange1 = new ColorRangeRGBA(255, 255, 255);
                colorRange2 = new ColorRangeRGBA(255, 255, 255);
                break;
            case TWOCOLORGRADIENT:
                colorRange1 = new ColorRangeRGBA(0, 0, 255);
                colorRange2 = new ColorRangeRGBA(0, 255, 0);
                break;
            default:
                colorRange1 = new ColorRangeRGBA(211, 211, 211);
                colorRange2 = new ColorRangeRGBA(169, 169, 169);
        }
    }
```

```
    public BackgroundProducerBuilder setColorRange1(ColorRangeRGBA
        colorRange1) {
        this.colorRange1 = colorRange1;
        return this;
    }

    public BackgroundProducerBuilder setColorRange2(ColorRangeRGBA
        colorRange2) {
        this.colorRange2 = colorRange2;
        return this;
    }

    @Override
    public BackgroundProducer create() {
        switch (type) {
            case FLATCOLOR:
                return new FlatColorBackgroundProducer(colorRange1,
                    colorRange2);
            case SQUIGGLES:
                return new SquigglesBackgroundProducer(colorRange1,
                    colorRange2);
            case TRANSPARENT:
                return new TransparentBackgroundProducer(colorRange1,
                    colorRange2);
            case TWOCOLORGRADIENT:
                return new TwoColorGradientBackgroundProducer(colorRange1,
                    colorRange2);
            default:
                throw new IllegalArgumentException("Background producer not
                    found: " + type.name());
        }
    }
}
```

Listing A.31: captchabuilder.elementcreator.producer.background.BackgroundProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
```

```
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background;

import java.awt.image.BufferedImage;

/**
 * BackgroundProducer.java (UTF-8)
 *
 * Interface for OO purposes
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.4
 * @version 1.0.7
 */
public interface BackgroundProducer {

    /**
     * Add the background to the given image.
     *
     * @param image The image onto which the background will be rendered.
     * @return The image with the background rendered.
     */
    public BufferedImage addBackground(BufferedImage image);

    public BufferedImage getBackground(int width, int height);
}
```

Listing A.32: captchabuilder.elementcreator.producer.background.FlatColorBackgroundProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
```

```
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import java.awt.Graphics2D;
import java.awt.geom.Rectangle2D;
import java.awt.image.BufferedImage;

/**
 * FlatColorBackgroundProducer.java (UTF-8)
 *
 * Generates a background in a single colour.
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.4
 * @version 1.1.0
 */
public class FlatColorBackgroundProducer extends AbstractBackgroundProducer
    {

    /**
     * constructor
     *
     * @param colorRange1 the first colour collection
     * @param colorRange2 the second colour collection
     */
    public FlatColorBackgroundProducer(ColorRangeRGBA colorRange1,
        ColorRangeRGBA colorRange2) {
        super(colorRange1, colorRange2);
    }

    @Override
    public BufferedImage getBackground(int width, int height) {
        BufferedImage img = new BufferedImage(width, height,
                BufferedImage.TYPE_INT_RGB);

        Graphics2D graphics = img.createGraphics();
        graphics.setPaint(colorRange1.getRandomColorInRange());
        graphics.fill(new Rectangle2D.Double(0, 0, width, height));
        graphics.drawImage(img, 0, 0, null);
        graphics.dispose();

        return img;
    }
}
```

Listing A.33: captchabuilder.elementcreator.producer.background.SquigglesBackgroundProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import java.awt.AlphaComposite;
import java.awt.BasicStroke;
import java.awt.Graphics2D;
import java.awt.geom.Arc2D;
import java.awt.image.BufferedImage;

/**
 * SquigglesBackgroundProducer.java (UTF-8)
 *
 * Generates a background of squiggles.
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.4
 * @version 1.1.0
 */
public class SquigglesBackgroundProducer extends AbstractBackgroundProducer
    {

    /**
     * constructor
     *
     * @param colorRange1 the first colour collection
     * @param colorRange2 the second colour collection
```

```
     */
    public SquigglesBackgroundProducer(ColorRangeRGBA colorRange1,
        ColorRangeRGBA colorRange2) {
        super(colorRange1, colorRange2);
    }

    @Override
    public BufferedImage getBackground(int width, int height) {
        BufferedImage result = new BufferedImage(width, height,
                BufferedImage.TYPE_INT_RGB);
        Graphics2D graphics = result.createGraphics();

        BasicStroke bs = new BasicStroke(2.0f, BasicStroke.CAP_BUTT,
            BasicStroke.JOIN_MITER, 2.0f, new float[]{2.0f, 2.0f}, 0.0f);
        graphics.setStroke(bs);
        AlphaComposite ac = AlphaComposite.getInstance(AlphaComposite.
            SRC_OVER,
                0.75f);
        graphics.setComposite(ac);

        graphics.translate(width * -1.0, 0.0);
        double delta = 15.0;
        double xt;
        for (xt = 0.0; xt < (2.0 * width); xt += delta) {
            Arc2D arc = new Arc2D.Double(0, 0, width, height, 0.0, 360.0,
                Arc2D.OPEN);
            graphics.draw(arc);
            graphics.translate(delta, 0.0);
        }
        graphics.dispose();
        return result;
    }
}
```

Listing A.34: captchabuilder.elementcreator.producer.background.TransparentBackgroundProduce

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
```

```
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import java.awt.AlphaComposite;
import java.awt.Graphics2D;
import java.awt.image.BufferedImage;

/**
 * TransparentBackgroundProducer.java (UTF-8)
 *
 * Generates a background transparent.
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.4
 * @version 1.1.0
 */
public class TransparentBackgroundProducer extends
    AbstractBackgroundProducer {

    /**
     * constructor
     *
     * @param colorRange1 the first colour collection
     * @param colorRange2 the second colour collection
     */
    public TransparentBackgroundProducer(ColorRangeRGBA colorRange1,
        ColorRangeRGBA colorRange2) {
        super(colorRange1, colorRange2);
    }

    @Override
    public BufferedImage getBackground(int width, int height) {
        BufferedImage bg = new BufferedImage(width, height, BufferedImage.
            TRANSLUCENT);
        Graphics2D g = bg.createGraphics();

        g.setComposite(AlphaComposite.getInstance(AlphaComposite.CLEAR, 0.0f
            ));
        g.fillRect(0, 0, width, height);

        return bg;
    }
}
```

Listing A.35: captchabuilder.elementcreator.producer.background.TwoColorGradientBackgroundProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
```

```
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import java.awt.GradientPaint;
import java.awt.Graphics2D;
import java.awt.RenderingHints;
import java.awt.geom.Rectangle2D;
import java.awt.image.BufferedImage;

/**
 * TwoColorGradientBackgroundProducer.java (UTF-8)
 *
 * Generates a background in a two colour horizontal gradient.
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.4
 * @version 1.1.0
 */
public class TwoColorGradientBackgroundProducer extends
    AbstractBackgroundProducer {

    /**
     * constructor
     *
     * @param colorRange1 the first colour collection
     * @param colorRange2 the second colour collection
     */
    public TwoColorGradientBackgroundProducer(ColorRangeRGBA colorRange1,
        ColorRangeRGBA colorRange2) {
        super(colorRange1, colorRange2);
```

```
    }

    @Override
    public BufferedImage getBackground(int width, int height) {
        // create an opaque image
        BufferedImage img = new BufferedImage(width, height,
                BufferedImage.TYPE_INT_RGB);

        Graphics2D g = img.createGraphics();
        RenderingHints hints = new RenderingHints(
                RenderingHints.KEY_ANTIALIASING,
                RenderingHints.VALUE_ANTIALIAS_ON);

        g.setRenderingHints(hints);

        // create the gradient color
        GradientPaint ytow = new GradientPaint(0, 0, colorRange1.
            getRandomColorInRange(), width, height,
                colorRange2.getRandomColorInRange());

        g.setPaint(ytow);
        // draw gradient color
        g.fill(new Rectangle2D.Double(0, 0, width, height));

        // draw the transparent image over the background
        g.drawImage(img, 0, 0, null);
        g.dispose();

        return img;
    }

}
```

Listing A.36: captchabuilder.elementcreator.producer.border.AbstractBorderProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
```

```
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.border;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import java.awt.AlphaComposite;
import java.awt.Graphics2D;
import java.awt.image.BufferedImage;

/**
 * AbstractBorderProducer.java (UTF-8)
 *
 * Abstract class template, implementing classes will generate borders.
 *
 * 2013/04/18
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.12
 * @version 1.1.0
 */
public abstract class AbstractBorderProducer implements BorderProducer {

    protected ColorRangeRGBA  colorRange;
    protected int thickness;

    protected AbstractBorderProducer(ColorRangeRGBA  colorRange, int
        thickness) {
        this.colorRange = colorRange;
        this.thickness = thickness;
    }

    @Override
    public void addBorder(BufferedImage img) {
        int width = img.getWidth();
        int height = img.getHeight();
        Graphics2D g = img.createGraphics();
        g.setComposite(AlphaComposite.getInstance(AlphaComposite.SRC_OVER,
            1.0f));
        g.setColor(colorRange.getRandomColorInRange());
        setStrokeOptions(g);
        g.drawLine(0, 0, 0, width);
        g.drawLine(0, 0, width, 0);
        g.drawLine(0, height, width, height);
        g.drawLine(width, height, width, 0);
    }
}
```

Listing A.37: captchabuilder.elementcreator.producer.border.BorderProducerBuilder

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
```

```
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.border;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.CaptchaElementCreatorBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    producer.BorderProducerType;

/**
 * BorderProducerBuilder.java (UTF-8)
 *
 * Builder for a background producer
 *
 * 2013/04/12
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.12
 * @version 1.0.12
 */
public class BorderProducerBuilder implements CaptchaElementCreatorBuilder {

    private ColorRangeRGBA colorRange;
    private int thickness;
    private BorderProducerType type;

    /**
     * constructor
     *
     * @param type the type of border producer to be created
     */
    public BorderProducerBuilder(BorderProducerType type) {
        this.type = type;
        this.colorRange = new ColorRangeRGBA(0);
```

```
        this.thickness = 1;
    }

    public BorderProducerBuilder setColorRange(ColorRangeRGBA colorRange) {
        this.colorRange = colorRange;
        return this;
    }

    public BorderProducerBuilder setThickness(int thickness) {
        this.thickness = thickness;
        return this;
    }

    @Override
    public BorderProducer create() {
        switch (type) {
            case SOLID:
                return new SolidBorderProducer(colorRange, thickness);
            default:
                throw new IllegalArgumentException("Border producer not
                    found: " + type.name());
        }
    }
}
```

Listing A.38: captchabuilder.elementcreator.producer.border.BorderProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.border;

import java.awt.Graphics2D;
```

```
import java.awt.image.BufferedImage;

/**
 * BorderProducer.java (UTF-8)
 *
 * Interface for OO purposes
 *
 * 2013/04/18
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.12
 * @version 1.0.12
 */
public interface BorderProducer {

    public void addBorder(BufferedImage img);

     public void setStrokeOptions(Graphics2D g);

}
```

Listing A.39: captchabuilder.elementcreator.producer.border.SolidBorderProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.border;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import java.awt.BasicStroke;
```

```
import java.awt.Graphics2D;

/**
 * SolidBorderProducer.java (UTF-8)
 *
 * Generates a solid border
 *
 * 2013/04/18
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.12
 * @version 1.1.0
 */
public class SolidBorderProducer extends AbstractBorderProducer {

    /**
     * constructor
     *
     * @param colorRange the colour collection to choose from
     * @param thickness the border thickness
     */
    public SolidBorderProducer(ColorRangeRGBA  colorRange, int thickness) {
        super(colorRange, thickness);
    }

    @Override
    public void setStrokeOptions(Graphics2D g) {
        g.setStroke(new BasicStroke(thickness));
    }

}
```

Listing A.40: captchabuilder.elementcreator.producer.noise.AbstractNoiseProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
```

```
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;

/**
 * AbstractNoiseProducer.java (UTF-8)
 *
 * Abstract class template, implementing classes will generate noise.
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.5
 * @version 1.1.0
 */
public abstract class AbstractNoiseProducer implements NoiseProducer {

    protected float thickness;
    protected ColorRangeRGBA colorRange;

    protected AbstractNoiseProducer(float thickness, ColorRangeRGBA
        colorRange) {
        this.thickness = thickness;
        this.colorRange = colorRange;
    }
}
```

Listing A.41: captchabuilder.elementcreator.producer.noise.CurvedLineNoiseProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
```

```
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import java.awt.BasicStroke;
import java.awt.Graphics2D;
import java.awt.RenderingHints;
import java.awt.geom.CubicCurve2D;
import java.awt.geom.PathIterator;
import java.awt.geom.Point2D;
import java.awt.image.BufferedImage;
import java.util.Random;

/**
 * CurvedLineNoiseProducer.java (UTF-8)
 *
 * generates curved line noise
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.5
 * @version 1.1.0
 */
public class CurvedLineNoiseProducer extends AbstractNoiseProducer {

    /**
     * constructor
     *
     * @param colorRange the colour collection to choose from
     * @param thickness the border thickness
     */
    public CurvedLineNoiseProducer(float thickness, ColorRangeRGBA
        colorRange) {
        super(thickness, colorRange);
    }

    @Override
    public void makeNoise(BufferedImage image) {
        Random RAND = CaptchaConstants.RANDOM;
        int width = image.getWidth();
        int height = image.getHeight();

        // the curve from where the points are taken
        CubicCurve2D cc = new CubicCurve2D.Float(width * .1f, height
                * RAND.nextFloat(), width * .1f, height
                * RAND.nextFloat(), width * .25f, height
                * RAND.nextFloat(), width * .9f, height
                * RAND.nextFloat());
```

```
        // creates an iterator to define the boundary of the flattened curve
        PathIterator pi = cc.getPathIterator(null, 2);
        Point2D tmp[] = new Point2D[200];
        int i = 0;

        // while pi is iterating the curve, adds points to tmp array
        while (!pi.isDone()) {
            float[] coords = new float[6];
            switch (pi.currentSegment(coords)) {
                case PathIterator.SEG_MOVETO:
                case PathIterator.SEG_LINETO:
                    tmp[i] = new Point2D.Float(coords[0], coords[1]);
            }
            i++;
            pi.next();
        }

        // the points where the line changes the stroke and direction
        Point2D[] pts = new Point2D[i];
        // copies points from tmp to pts
        System.arraycopy(tmp, 0, pts, 0, i);

        Graphics2D graph = (Graphics2D) image.getGraphics();
        graph.setRenderingHints(new RenderingHints(
                RenderingHints.KEY_ANTIALIASING,
                RenderingHints.VALUE_ANTIALIAS_ON));

        graph.setColor(colorRange.getRandomColorInRange());

        // for the maximum 3 point change the stroke and direction
        for (i = 0; i < pts.length - 1; i++) {
            if (i < 3) {
                graph.setStroke(new BasicStroke(thickness));
            }
            graph.drawLine((int) pts[i].getX(), (int) pts[i].getY(),
                    (int) pts[i + 1].getX(), (int) pts[i + 1].getY());
        }

        graph.dispose();
    }
}
```

Listing A.42: captchabuilder.elementcreator.producer.noise.NoiseProducerBuilder

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
```

```
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.CaptchaElementCreatorBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    producer.NoiseProducerType;

/**
 * NoiseProducerBuilder.java (UTF-8)
 *
 * builder for a noise producer
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.5
 * @version 1.1.0
 */
public class NoiseProducerBuilder implements CaptchaElementCreatorBuilder {

    private float thickness;
    private ColorRangeRGBA colorRange;
    private NoiseProducerType type;

    /**
     * constructor
     *
     * @param type the type of noise producer to be created
     */
    public NoiseProducerBuilder(NoiseProducerType type) {
        this.colorRange = new ColorRangeRGBA(0);
        this.type = type;
        this.thickness = 3.5f;
    }

    public NoiseProducerBuilder setThickness(float thickness) {
        this.thickness = thickness;
        return this;
    }

    public NoiseProducerBuilder setColorRange(ColorRangeRGBA colorRange) {
        this.colorRange = colorRange;
```

```
        return this;
    }

    @Override
    public NoiseProducer create() {
        switch (type) {
            case CURVEDLINE:
                return new CurvedLineNoiseProducer(thickness, colorRange);
            case STRAIGHTLINE:
                return new StraightLineNoiseProducer(thickness, colorRange);
            default:
                throw new IllegalArgumentException("NoiseProduder not found:
                    " + type.name());
        }
    }
}
```

Listing A.43: captchabuilder.elementcreator.producer.noise.NoiseProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise;

import java.awt.image.BufferedImage;

/**
 * NoiseProducer.java (UTF-8)
 *
 * Interface for OO purposes
 *
 * 2013/04/16
 *
```

```
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.5
 * @version 1.0.7
 */
public interface NoiseProducer {

    public void makeNoise(BufferedImage image);
}
```

Listing A.44: captchabuilder.elementcreator.producer.noise.StraightLineNoiseProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import java.awt.Graphics;
import java.awt.Graphics2D;
import java.awt.image.BufferedImage;

/**
 * StraightLineNoiseProducer.java (UTF-8)
 *
 * generates straight line noise
 *
 * 2013/04/16
 *
```

```
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.5
 * @version 1.1.0
 */
public class StraightLineNoiseProducer extends AbstractNoiseProducer {

    /**
     * constructor
     *
     * @param colorRange the colour collection to choose from
     * @param thickness the border thickness
     */
    public StraightLineNoiseProducer(float thickness, ColorRangeRGBA
        colorRange) {
        super(thickness, colorRange);
    }

    @Override
    public void makeNoise(BufferedImage image) {
        Graphics2D graphics = image.createGraphics();
        int height = image.getHeight();
        int width = image.getWidth();
        int y1 = CaptchaConstants.RANDOM.nextInt(height) + 1;
        int y2 = CaptchaConstants.RANDOM.nextInt(height) + 1;
        drawLine(graphics, y1, width, y2);
    }

    private void drawLine(Graphics g, int y1, int x2, int y2) {
        int X1 = 0;

        // The thick line is in fact a filled polygon
        g.setColor(colorRange.getRandomColorInRange());
        int dX = x2 - X1;
        int dY = y2 - y1;
        // line length
        double lineLength = Math.sqrt(dX * dX + dY * dY);

        double scale = thickness / (2 * lineLength);

        // The x and y increments from an endpoint needed to create a
        // rectangle...
        double ddx = -scale * dY;
        double ddy = scale * dX;
        ddx += (ddx > 0) ? 0.5 : -0.5;
        ddy += (ddy > 0) ? 0.5 : -0.5;
        int dx = (int) ddx;
        int dy = (int) ddy;

        // Now we can compute the corner points...
        int xPoints[] = new int[4];
        int yPoints[] = new int[4];

        xPoints[0] = X1 + dx;
        yPoints[0] = y1 + dy;
        xPoints[1] = X1 - dx;
        yPoints[1] = y1 - dy;
        xPoints[2] = x2 - dx;
        yPoints[2] = y2 - dy;
        xPoints[3] = x2 + dx;
        yPoints[3] = y2 + dy;
```

```
            g.fillPolygon(xPoints, yPoints, 4);
        }
}
```

Listing A.45: captchabuilder.elementcreator.producer.text.AbstractTextProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ArrayUtil;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;

/**
 * AbstractTextProducer.java (UTF-8)
 *
 * Abstract class template, implementing classes will generate text.
 *
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.2
 * @version 1.0.7
 */
public abstract class AbstractTextProducer extends ArrayUtil<Character>
    implements TextProducer {
```

```
    private final char[] _srcChars;
    private int _minLength;
    private int _maxLength;

    protected AbstractTextProducer(char[] chars, int minLenght, int
        maxLenght) {
        _minLength = minLenght;
        _maxLength = maxLenght;
        _srcChars = chars;
    }

    @Override
    public String getText() {
        String capText = "";
        int _length = Math.max(_minLength, CaptchaConstants.RANDOM.nextInt(
            _maxLength));
        for (int i = 0; i < _length; i++) {
            capText += _srcChars[CaptchaConstants.RANDOM.nextInt(_srcChars.
                length)];
        }

        return capText;
    }

    /*
     * No Longer used
     *
     * private static char[] copyOf(char[] original, int newLength) {
     *   char[] copy = new char[newLength];
     *   System.arraycopy(original, 0, copy, 0,
     *            Math.min(original.length, newLength));
     *   return copy;
     * }
     */

    public void setLength(int minLength, int maxLength) {
        if (minLength < 0 || maxLength < minLength) {
            this._minLength = minLength;
        }
        this._maxLength = maxLength;
    }
}
```

Listing A.46: captchabuilder.elementcreator.producer.text.AlphanumericTextProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
```

```
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;

/**
 * AlphanumericTextProducer.java (UTF-8)
 *
 * generates alphanumerical text
 *
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.2
 * @version 1.0.7
 */
public class AlphanumericTextProducer extends AbstractTextProducer {

    /**
     * constructor
     *
     * @param minLenght the minimum text length
     * @param maxLenght the maximum text length
     */
    public AlphanumericTextProducer(int minLenght, int maxLenght) {
        super(concat(CaptchaConstants.LETTERS, CaptchaConstants.NUMBERS),
            minLenght, maxLenght);
    }
}
```

Listing A.47: captchabuilder.elementcreator.producer.text.ArabicTextProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
```

```
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;

/**
 * ArabicTextProducer.java (UTF-8)
 *
 * generates Arabic letters
 *
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.2
 * @version 1.0.7
 */
public class ArabicTextProducer extends AbstractTextProducer {

    /**
     * constructor
     *
     * @param minLenght the minimum text length
     * @param maxLenght the maximum text length
     */
    public ArabicTextProducer(int minLenght, int maxLenght) {
        // I hope we don't generate something offensive
        super(CaptchaConstants.ARABIC_CHARS, minLenght, maxLenght);
    }
}
```

Listing A.48: captchabuilder.elementcreator.producer.text.ChineseTextProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
```

```
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

/**
 * ChineseTextProducer.java (UTF-8)
 *
 * generates Chinese tokens
 *
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.2
 * @version 1.0.7
 */
public class ChineseTextProducer extends AbstractTextProducer {

    /**
     * constructor
     *
     * @param minLenght the minimum text length
     * @param maxLenght the maximum text length
     */
    public ChineseTextProducer(int minLenght, int maxLenght) {
        super(buildChineseCharset(), minLenght, maxLenght);
    }

    private static char[] buildChineseCharset() {
        // Here's hoping none of the characters in this range are offensive.
        int CODE_POINT_START = 0x4E00;
        int CODE_POINT_END = 0x4F6F;
        int NUM_CHARS = CODE_POINT_END - CODE_POINT_START;
        char[] CHARS;

        CHARS = new char[NUM_CHARS];
        for (char c = (char) CODE_POINT_START, i = 0; c < CODE_POINT_END; c
            ++, i++) {
            CHARS[i] = Character.valueOf(c);
```

```
        }

        return CHARS;
    }
}
```

Listing A.49: captchabuilder.elementcreator.producer.text.LetterTextProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;

/**
 * LetterTextProducer.java (UTF-8)
 *
 * generates letters
 *
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.1
 * @version 1.0.7
 */
public class LetterTextProducer extends AbstractTextProducer {

    /**
     * constructor
```

```
     *
     * @param minLenght the minimum text length
     * @param maxLenght the maximum text length
     */
    public LetterTextProducer(int minLenght, int maxLenght) {
        super(CaptchaConstants.LETTERS, minLenght, maxLenght);
    }
}
```

Listing A.50: captchabuilder.elementcreator.producer.text.NumbersProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;

/**
 * NumbersProducer.java (UTF-8)
 *
 * generates numbers
 *
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.2
 * @version 1.0.7
 */
public class NumbersProducer extends AbstractTextProducer {
```

```
/**
     * constructor
     *
     * @param minLenght the minimum text length
     * @param maxLenght the maximum text length
     */
    public NumbersProducer(int minLenght, int maxLenght) {
        super(CaptchaConstants.NUMBERS, minLenght, maxLenght);
    }
}
```

Listing A.51: captchabuilder.elementcreator.producer.text.ReducedAlphanumericTextProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;

/**
 * ReducedAlphanumericTextProducer.java (UTF-8)
 *
 * generates reduced alphanumerical text
 *
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.2
 * @version 1.0.7
```

```
 */
public class ReducedAlphanumericTextProducer extends AbstractTextProducer {

    /**
     * constructor
     *
     * @param minLenght the minimum text length
     * @param maxLenght the maximum text length
     */
    public ReducedAlphanumericTextProducer(int minLenght, int maxLenght) {
        super(CaptchaConstants.REDUCEDALPHANUMERIC, minLenght, maxLenght);
    }
}
```

Listing A.52: captchabuilder.elementcreator.producer.text.SpecialAlphanumericTextProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;

/**
 * SpecialAlphanumericTextProducer.java (UTF-8)
 *
 * generates alphanumerical text with special tokens
 *
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
```

```
 * @author Hogent StudentID <2000901295>
 * @since 1.0.1
 * @version 1.0.7
 */
public class SpecialAlphanumericTextProducer extends AbstractTextProducer {

    /**
     * constructor
     *
     * @param minLenght the minimum text length
     * @param maxLenght the maximum text length
     */
    public SpecialAlphanumericTextProducer(int minLenght, int maxLenght) {
        super(concat(CaptchaConstants.LETTERS, CaptchaConstants.NUMBERS,
            CaptchaConstants.SPECIAL), minLenght, maxLenght);
    }
}
```

Listing A.53: captchabuilder.elementcreator.producer.text.SpecialLetterTextProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;

/**
 * SpecialLetterTextProducer.java (UTF-8)
 *
 * generates letters with special tokens
 *
```

```
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.1
 * @version 1.0.7
 */
public class SpecialLetterTextProducer extends AbstractTextProducer {

    /**
     * constructor
     *
     * @param minLenght the minimum text length
     * @param maxLenght the maximum text length
     */
    public SpecialLetterTextProducer(int minLenght, int maxLenght) {
        super(concat(CaptchaConstants.LETTERS, CaptchaConstants.SPECIAL),
            minLenght, maxLenght);
    }
}
```

Listing A.54: captchabuilder.elementcreator.producer.text.SpecialNumbersProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;

/**
```

```
 * SpecialNumbersProducer.java (UTF-8)
 *
 * generates numerical text with special tokens
 *
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.1
 * @version 1.0.7
 */
public class SpecialNumbersProducer extends AbstractTextProducer {

    /**
     * constructor
     *
     * @param minLenght the minimum text length
     * @param maxLenght the maximum text length
     */
    public SpecialNumbersProducer(int minLenght, int maxLenght) {
        super(concat(CaptchaConstants.NUMBERS, CaptchaConstants.SPECIAL),
            minLenght, maxLenght);
    }
}
```

Listing A.55: captchabuilder.elementcreator.producer.text.TextProducerBuilder

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;
```

```
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.CaptchaElementCreatorBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    producer.TextProducerType;

/**
 * TextProducerBuilder.java (UTF-8)
 *
 * Builder for a text producer
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.3
 * @version 1.0.13
 */
public class TextProducerBuilder implements CaptchaElementCreatorBuilder {

    private int minLenght;
    private int maxLenght;
    private TextProducerType type;

    /**
     * constructor
     *
     * @param type the type of text producer to be created
     */
    public TextProducerBuilder(TextProducerType type) {
        this.minLenght = CaptchaConstants.DEFAULT_LENGTH;
        this.maxLenght = CaptchaConstants.DEFAULT_LENGTH;
        this.type = type;
    }

    public TextProducerBuilder setLenght(int minLenght, int maxLenght) {
        this.minLenght = minLenght;
        this.maxLenght = maxLenght;
        return this;
    }

    public TextProducerBuilder setMinLenght(int minLenght) {
        this.minLenght = minLenght;
        return this;
    }

    public TextProducerBuilder setMaxLenght(int maxLenght) {
        this.maxLenght = maxLenght;
        return this;
    }

    @Override
    public TextProducer create() {
        switch (type) {
            case ALPHANUMERIC:
                return new AlphanumericTextProducer(minLenght, maxLenght);
            case REDUCED_ALPHANUMERIC:
                return new ReducedAlphanumericTextProducer(minLenght,
                    maxLenght);
            case CHINESE:
```

```
                return new ChineseTextProducer(minLenght, maxLenght);
            case ARABIC:
                return new ArabicTextProducer(minLenght, maxLenght);
            case NUMBERS:
                return new NumbersProducer(minLenght, maxLenght);
            case LETTERS:
                return new LetterTextProducer(minLenght, maxLenght);
            case LETTERS_SPECIAL:
                return new SpecialLetterTextProducer(minLenght, maxLenght);
            case NUMBERS_SPECIAL:
                return new SpecialNumbersProducer(minLenght, maxLenght);
            case ALPHANUMERIC_SPECIAL:
                return new SpecialAlphanumericTextProducer(minLenght,
                    maxLenght);
            default:
                throw new IllegalArgumentException("TextProducer not found:
                    " + type.name());
        }
    }
}
```

Listing A.56: captchabuilder.elementcreator.producer.text.TextProducer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text;

/**
 * TextProducer.java (UTF-8)
 *
 * Interface for OO purposes
 *
```

```
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.4
 * @version 1.0.7
 */
public interface TextProducer {

    public String getText();
}
```

Listing A.57: captchabuilder.elementcreator.renderer.gimpy.AbstractGimpyRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;

/**
 * AbstractGimpyRenderer.java (UTF-8)
 *
 * Abstract class template, implementing classes will generate distortions.
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
```

```
 * @since 1.0.6
 * @version 1.1.0
 */
public abstract class AbstractGimpyRenderer implements GimpyRenderer {

    protected double d1;
    protected double d2;
    protected ColorRangeRGBA colorRange1;
    protected ColorRangeRGBA colorRange2;

    protected AbstractGimpyRenderer(double d1, double d2, ColorRangeRGBA
        colorRange1, ColorRangeRGBA colorRange2) {
        this.d1 = d1;
        this.d2 = d2;
        this.colorRange1 = colorRange1;
        this.colorRange2 = colorRange2;
    }
}
```

Listing A.58: captchabuilder.elementcreator.renderer.gimpy.BlockGimpyRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy;


import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ImageUtil;
import java.awt.image.BufferedImage;
import com.jhlabs.image.BlockFilter;
```

```
/**
 * BlockGimpyRenderer.java (UTF-8)
 *
 * generates block transformations
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.6
 * @version 1.1.0
 */
public class BlockGimpyRenderer extends AbstractGimpyRenderer {

    public BlockGimpyRenderer(double d1, double d2, ColorRangeRGBA
        colorRange1, ColorRangeRGBA colorRange2) {
        super(d1, d2, colorRange1, colorRange2);
    }

    @Override
    public void gimp(BufferedImage image) {
        BlockFilter filter = new BlockFilter();
        filter.setBlockSize((int) d1);
        ImageUtil.applyFilter(image, filter);
    }
}
```

Listing A.59: captchabuilder.elementcreator.renderer.gimpy.DropShadowGimpyRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
```

```
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ImageUtil;
import java.awt.image.BufferedImage;

import com.jhlabs.image.ShadowFilter;

/**
 * DropShadowGimpyRenderer.java (UTF-8)
 *
 * generates dropshadow transformations
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.6
 * @version 1.1.0
 */
public class DropShadowGimpyRenderer extends AbstractGimpyRenderer {

    protected DropShadowGimpyRenderer(double d1, double d2, ColorRangeRGBA
        colorRange1, ColorRangeRGBA colorRange2) {
        super(d1, d2, colorRange1, colorRange2);
    }

    @Override
    public void gimp(BufferedImage image) {
        ShadowFilter sFilter = new ShadowFilter();
        sFilter.setRadius((int) d1);
        sFilter.setOpacity((int) d2);
        sFilter.setShadowColor(colorRange1.getRandomColorInRange().getRGB())
            ;
        ImageUtil.applyFilter(image, sFilter);
    }
}
```

Listing A.60: captchabuilder.elementcreator.renderer.gimpy.FishEyeGimpyRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
```

```
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import java.awt.image.BufferedImage;

import java.awt.Graphics2D;


/**
 * StretchGimpyRenderer.java (UTF-8)
 *
 * generates fisheye transformations
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.6
 * @version 1.1.0
 */
public class FishEyeGimpyRenderer extends AbstractGimpyRenderer {

    public FishEyeGimpyRenderer(double d1, double d2, ColorRangeRGBA
        colorRange1, ColorRangeRGBA colorRange2) {
        super(d1, d2, colorRange1, colorRange2);
    }

    @Override
    public void gimp(BufferedImage image) {
        int height = image.getHeight();
        int width = image.getWidth();

        int hstripes = (int) (height / d1);
        int vstripes = (int) (width / d2);

        // Calculate space between lines
        int hspace = height / (hstripes + 1);
        int vspace = width / (vstripes + 1);

        Graphics2D graph = (Graphics2D) image.getGraphics();
        // Draw the horizontal stripes
        for (int i = hspace; i < height; i = i + hspace) {
            graph.setColor(colorRange1.getRandomColorInRange());
            graph.drawLine(0, i, width, i);
        }
```

```
        // Draw the vertical stripes
        for (int i = vspace; i < width; i = i + vspace) {
            graph.setColor(colorRange2.getRandomColorInRange());
            graph.drawLine(i, 0, i, height);
        }

        // Create a pixel array of the original image.
        // we need this later to do the operations on..
        int pix[] = new int[height * width];
        int j = 0;

        for (int j1 = 0; j1 < width; j1++) {
            for (int k1 = 0; k1 < height; k1++) {
                pix[j] = image.getRGB(j1, k1);
                j++;
            }
        }

        double distance = ranInt(width / 4, width / 3);

        // put the distortion in the (dead) middle
        int wMid = image.getWidth() / 2;
        int hMid = image.getHeight() / 2;

        // again iterate over all pixels..
        for (int x = 0; x < image.getWidth(); x++) {
            for (int y = 0; y < image.getHeight(); y++) {

                int relX = x - wMid;
                int relY = y - hMid;

                double d1 = Math.sqrt(relX * relX + relY * relY);
                if (d1 < distance) {

                    int j2 = wMid
                            + (int) (((fishEyeFormula(d1 / distance) *
                                distance) / d1) * (x - wMid));
                    int k2 = hMid
                            + (int) (((fishEyeFormula(d1 / distance) *
                                distance) / d1) * (y - hMid));
                    image.setRGB(x, y, pix[j2 * height + k2]);
                }
            }
        }

        graph.dispose();
    }

    private final int ranInt(int i, int j) {
        double d = Math.random();
        return (int) (i + ((j - i) + 1) * d);
    }

    private final double fishEyeFormula(double s) {
        // implementation of:
        // g(s) = - (3/4)s3 + (3/2)s2 + (1/4)s, with s from 0 to 1.
        if (s < 0.0D) {
            return 0.0D;
        }
        if (s > 1.0D) {
            return s;
        }
```

```
        return -0.75D * s * s * s + 1.5D * s * s + 0.25D * s;
    }
}
```

Listing A.61: captchabuilder.elementcreator.renderer.gimpy.GimpyRendererBuilder

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.CaptchaElementCreatorBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    renderer.GimpyRendererType;

/**
 * GimpyRendererBuilder.java (UTF-8)
 *
 * Builder for a transformation renderer
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.6
 * @version 1.1.0
 */
public class GimpyRendererBuilder implements CaptchaElementCreatorBuilder {
```

```
    private double d1;
    private double d2;
    private ColorRangeRGBA colorRange1;
    private ColorRangeRGBA colorRange2;
    private GimpyRendererType type;

    public GimpyRendererBuilder(GimpyRendererType type) {
        this.colorRange1 = new ColorRangeRGBA(211, 211, 211);
        this.colorRange2 = new ColorRangeRGBA(169, 169, 169);

        this.d1 = 3.0;
        this.d2 = 75;
        this.type = type;
        if (type.equals(GimpyRendererType.STRETCH)) {
            this.d2 = 3.0;
        }
        if (type.equals(GimpyRendererType.RIPPLE)) {
            this.d1 = 2.6;
            this.d2 = 1.7;
        }
    }

    public GimpyRendererBuilder setD1(double d1) {
        this.d1 = d1;
        return this;
    }

    public GimpyRendererBuilder setD2(double d2) {
        this.d2 = d2;
        return this;
    }

    public GimpyRendererBuilder setColorRange1(ColorRangeRGBA colorRange1) {
        this.colorRange1 = colorRange1;
        return this;
    }

    public GimpyRendererBuilder setColorRange2(ColorRangeRGBA  colorRange2)
        {
        this.colorRange2 = colorRange2;
        return this;
    }

    @Override
    public GimpyRenderer create() {
        switch (type) {
            case BLOCK:
                return new BlockGimpyRenderer(d1, d2, colorRange1,
                    colorRange2);
            case DROPSHADOW:
                return new DropShadowGimpyRenderer(d1, d2, colorRange1,
                    colorRange2);
            case FISHEYE:
                return new FishEyeGimpyRenderer(d1, d2, colorRange1,
                    colorRange2);
            case RIPPLE:
                return new RippleGimpyRenderer(d1, d2, colorRange1,
                    colorRange2);
            case SHEAR:
                return new ShearGimpyRenderer(d1, d2, colorRange1,
                    colorRange2);
```

```
            case STRETCH:
                return new StretchGimpyRenderer(d1, d2, colorRange1,
                    colorRange2);
            default:
                throw new IllegalArgumentException("GimpyRenderer not found:
                    " + type.name());
        }
    }
}
```

Listing A.62: captchabuilder.elementcreator.renderer.gimpy.GimpyRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy;

import java.awt.image.BufferedImage;

/**
 * GimpyRenderer.java (UTF-8)
 *
 * Interface for OO purposes
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.6
 * @version 1.0.7
 */
public interface GimpyRenderer {
```

```
    public void gimp(BufferedImage image);
}
```

Listing A.63: captchabuilder.elementcreator.renderer.gimpy.RippleGimpyRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ImageUtil;
import com.jhlabs.image.RippleFilter;
import com.jhlabs.image.TransformFilter;
import java.awt.image.BufferedImage;

/**
 * RippleGimpyRenderer.java (UTF-8)
 *
 * generates ripple transformations
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.6
 * @version 1.1.0
 */
public class RippleGimpyRenderer extends AbstractGimpyRenderer {
```

```
    public RippleGimpyRenderer(double d1, double d2, ColorRangeRGBA
        colorRange1, ColorRangeRGBA colorRange2) {
        super(d1, d2, colorRange1, colorRange2);
    }

    @Override
    public void gimp(BufferedImage image) {
        RippleFilter filter = new RippleFilter();
        filter.setWaveType(RippleFilter.SINGLEFRAME);
        filter.setXAmplitude(d1);
        filter.setYAmplitude(d2);
        filter.setXWavelength((5.77)*d1);
        filter.setYWavelength((2.94)*d2);

        filter.setEdgeAction(TransformFilter.RANDOMPIXELORDER);

        ImageUtil.applyFilter(image, filter);
    }
}
```

Listing A.64: captchabuilder.elementcreator.renderer.gimpy.ShearGimpyRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import java.awt.image.BufferedImage;
```

```
import java.awt.Graphics2D;
import java.util.Random;

/**
 * ShearGimpyRenderer.java (UTF-8)
 *
 * generates shear transformations
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.6
 * @version 1.1.0
 */
public class ShearGimpyRenderer extends AbstractGimpyRenderer {

    private Random random;

    public ShearGimpyRenderer(double d1, double d2, ColorRangeRGBA
        colorRange1, ColorRangeRGBA colorRange2) {
        super(d1, d2, colorRange1, colorRange2);
        this.random = CaptchaConstants.RANDOM;
    }

    @Override
    public void gimp(BufferedImage bi) {
        Graphics2D g = bi.createGraphics();
        shearX(g, bi.getWidth(), bi.getHeight());
        shearY(g, bi.getWidth(), bi.getHeight());
        g.dispose();
    }

    private void shearX(Graphics2D g, int w1, int h1) {

        int period = random.nextInt(10) + 5;

        boolean borderGap = true;
        int frames = 15;
        int phase = random.nextInt(5) + 2;

        for (int i = 0; i < h1; i++) {
            double d = (period >> 1)
                    * Math.sin((double) i / (double) period
                    + (6.283185307179862D * phase) / frames);
            g.copyArea(0, i, w1, 1, (int) d, 0);
            if (borderGap) {
                g.setColor(colorRange1.getRandomColorInRange());
                g.drawLine((int) d, i, 0, i);
                g.drawLine((int) d + w1, i, w1, i);
            }
        }
    }

    private void shearY(Graphics2D g, int w1, int h1) {
        int period = random.nextInt(30) + 10; // 50;

        boolean borderGap = true;
        int frames = 15;
        int phase = 7;
        for (int i = 0; i < w1; i++) {
```

```
            double d = (period >> 1)
                    * Math.sin((float) i / period
                    + (6.2831853071795862D * phase) / frames);
            g.copyArea(i, 0, 1, h1, 0, (int) d);
            if (borderGap) {
                g.setColor(colorRange1.getRandomColorInRange());
                g.drawLine(i, (int) d, i, 0);
                g.drawLine(i, (int) d + h1, i, h1);
            }
        }
    }
}
```

Listing A.65: captchabuilder.elementcreator.renderer.gimpy.StretchGimpyRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy;


import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import java.awt.image.BufferedImage;

import java.awt.Graphics2D;
import java.awt.geom.AffineTransform;

/**
 * StretchGimpyRenderer.java (UTF-8)
 *
 * generates stretch transformations
 *
```

```
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.6
 * @version 1.1.0
 */
public class StretchGimpyRenderer extends AbstractGimpyRenderer {

    public StretchGimpyRenderer(double d1, double d2, ColorRangeRGBA
        colorRange1, ColorRangeRGBA colorRange2) {
        super(d1, d2, colorRange1, colorRange2);
    }

    @Override
    public void gimp(BufferedImage image) {
        Graphics2D g = image.createGraphics();
        AffineTransform at = new AffineTransform();
        at.scale(d1, d2);
        g.drawRenderedImage(image, at);
    }
}
```

Listing A.66: captchabuilder.elementcreator.renderer.text.AbstractWordRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
```

```
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import java.awt.Font;
import java.awt.Graphics2D;
import java.awt.RenderingHints;
import java.awt.font.FontRenderContext;
import java.awt.image.BufferedImage;
import java.util.ArrayList;
import java.util.List;

/**
 * AbstractWordRenderer.java (UTF-8)
 *
 * Abstract class template, implementing classes will generate word styles.
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.3
 * @version 1.1.0
 */
public abstract class AbstractWordRenderer implements WordRenderer {

    public static final ColorRangeRGBA DEFAULT_COLOR_RANGE;
    public static final List<Font> DEFAULT_FONTS = new ArrayList<>();

    static {
        DEFAULT_COLOR_RANGE = new ColorRangeRGBA(0);
        DEFAULT_FONTS.add(new Font("Arial", Font.BOLD, 40));
//          DEFAULT_FONTS.add(new Font("Courier", Font.BOLD, 40));
    }
    protected ColorRangeRGBA colorRange;
    protected List<Font> fonts;
    private double xOffset;
    private double yOffset;
    protected float strokeWidth;
    protected Graphics2D g;
    protected FontRenderContext frc;

    /**
     * Build a
     * <code>WordRenderer</code> using the given
     * <code>Color</code>s and
     * <code>Font</code>s.
     *
     * @param colorRange
     * @param fonts
     */
    public AbstractWordRenderer(ColorRangeRGBA colorRange, List<Font> fonts,
         double xOffset, double yOffset, float strokeWidth) {
        this.colorRange = colorRange;
        this.fonts = fonts;
        this.xOffset = xOffset;
        this.yOffset = yOffset;
        this.strokeWidth = strokeWidth;
    }

    /**
     * Render a word onto a BufferedImage.
     *
```

```
     * @param word The word to be rendered.
     * @param image The BufferedImage onto which the word will be painted.
     */
    protected void preRender(BufferedImage image) {
        g = image.createGraphics();

        RenderingHints hints = new RenderingHints(
                RenderingHints.KEY_ANTIALIASING,
                RenderingHints.VALUE_ANTIALIAS_ON);
        hints.add(new RenderingHints(RenderingHints.KEY_RENDERING,
                RenderingHints.VALUE_RENDER_QUALITY));
        g.setRenderingHints(hints);

        frc = g.getFontRenderContext();
    }

    protected int getXBaseline(BufferedImage image) {
        return (int) Math.round(image.getWidth() * xOffset);
    }

    protected int getYBaseline(BufferedImage image) {
        return image.getHeight() - (int) Math.round(image.getHeight() *
            yOffset);
    }

    protected Font getRandomFont() {
        return (Font) getRandomObject(fonts);
    }

    public Object getRandomObject(List<? extends Object> objs) {
        if (objs.size() == 1) {
            return objs.get(0);
        }

        int i = CaptchaConstants.RANDOM.nextInt(objs.size());
        return objs.get(i);
    }
}
```

Listing A.67: captchabuilder.elementcreator.renderer.text.ColoredEdgesWordRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
```

```
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text;


import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import java.awt.BasicStroke;
import java.awt.Font;
import java.awt.Shape;
import java.awt.font.TextAttribute;
import java.awt.font.TextLayout;
import java.awt.geom.AffineTransform;
import java.awt.image.BufferedImage;
import java.text.AttributedCharacterIterator;
import java.text.AttributedString;
import java.util.List;

/**
 * ColoredEdgesWordRenderer.java (UTF-8)
 *
 * generates coloured edges font style
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.3
 * @version 1.1.0
 */
public class ColoredEdgesWordRenderer extends AbstractWordRenderer {

    public ColoredEdgesWordRenderer(ColorRangeRGBA colorRange, List<Font>
        fonts, double xOffset, double yOffset, float strokeWidth) {
        super(colorRange, fonts, xOffset, yOffset, strokeWidth);
    }

    @Override
    public void render(String word, BufferedImage bi) {
        preRender(bi);
        int xBaseline = getXBaseline(bi);
        int yBaseline = getYBaseline(bi);

        AttributedString as = new AttributedString(word);
        as.addAttribute(TextAttribute.FONT, getRandomFont());
        AttributedCharacterIterator aci = as.getIterator();

        TextLayout tl = new TextLayout(aci, frc);

        Shape shape = tl.getOutline(AffineTransform.getTranslateInstance(
            xBaseline, yBaseline));
```

```
        g.setColor(colorRange.getRandomColorInRange());
        g.setStroke(new BasicStroke(strokeWidth));

        g.draw(shape);
    }
}
```

Listing A.68: captchabuilder.elementcreator.renderer.text.DefaultWordRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */

package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import java.awt.Font;
import java.awt.font.GlyphVector;
import java.awt.image.BufferedImage;
import java.util.List;

/**
 * DefaultWordRenderer.java (UTF-8)
 *
 * generates solid font style
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
```

```
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.3
 * @version 1.1.0
 */
public class DefaultWordRenderer extends AbstractWordRenderer {

    public DefaultWordRenderer(ColorRangeRGBA colorRange, List<Font> fonts,
        double xOffset, double yOffset, float strokeWidth) {
        super(colorRange, fonts, xOffset, yOffset, strokeWidth);
    }

    @Override
    public void render(String word, BufferedImage bi) {
        preRender(bi);
        int xBaseline = getXBaseline(bi);
        int yBaseline =  getYBaseline(bi);

        char[] chars = new char[1];
        for (char c : word.toCharArray()) {
            chars[0] = c;

            g.setColor(colorRange.getRandomColorInRange());

            int choiceFont = CaptchaConstants.RANDOM.nextInt(fonts.size());
            Font font = fonts.get(choiceFont);
            g.setFont(font);

            GlyphVector gv = font.createGlyphVector(frc, chars);
            g.drawChars(chars, 0, chars.length, xBaseline, yBaseline);

            int width = (int) gv.getVisualBounds().getWidth();
            xBaseline = xBaseline + width;
        }
    }


}
```

Listing A.69: captchabuilder.elementcreator.renderer.text.WordRendererBuilder

```
/*
 * The MIT License
 *
 * Copyright 2013 piva.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
```

```
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */

package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.CaptchaElementCreatorBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.
    ColorRangeRGBA;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    CaptchaConstants;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums.
    renderer.WordRendererType;
import java.awt.Font;
import java.util.List;

/**
 * WordRendererBuilder.java (UTF-8)
 *
 * Builder for a word style renderer
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.3
 * @version 1.1.0
 */
public class WordRendererBuilder implements CaptchaElementCreatorBuilder {
    private ColorRangeRGBA colorRange;
    private List<Font> fonts;
    private double xOffset;
    private double yOffset;
    private float strokeWidth;
    private WordRendererType type;

    public WordRendererBuilder(WordRendererType type) {
        this.strokeWidth = CaptchaConstants.DEFAULT_STROKE_WIDTH;
        this.yOffset = CaptchaConstants.DEFAULT_YOFFSET;
        this.xOffset = CaptchaConstants.DEFAULT_XOFFSET;
        this.fonts = AbstractWordRenderer.DEFAULT_FONTS;
        this.colorRange = AbstractWordRenderer.DEFAULT_COLOR_RANGE;
        this.type = type;
    }

    public WordRendererBuilder setColorRange(ColorRangeRGBA colorRange) {
        this.colorRange = colorRange;
        return this;
    }

    public WordRendererBuilder setFonts(List<Font> fonts) {
```

```
        this.fonts = fonts;
        return this;
    }

    public WordRendererBuilder setXOffset(double xOffset) {
        this.xOffset = xOffset;
        return this;
    }

    public WordRendererBuilder setYOffset(double yOffset) {
        this.yOffset = yOffset;
        return this;
    }

    public WordRendererBuilder setStrokeWidth(float strokeWidth) {
        this.strokeWidth = strokeWidth;
        return this;
    }

    @Override
    public WordRenderer create() {
        switch (type) {
            case DEFAULT:
                return new DefaultWordRenderer(colorRange, fonts, xOffset,
                    yOffset, strokeWidth);
            case COLOREDEDGES:
                return new ColoredEdgesWordRenderer(colorRange, fonts,
                    xOffset, yOffset, strokeWidth);
            default:
                throw new IllegalArgumentException("WordRenderer not found:
                    " + type.name());
        }
    }

}
```

Listing A.70: captchabuilder.elementcreator.renderer.text.WordRenderer

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
```

```
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text;

import java.awt.image.BufferedImage;

/**
 * WordRenderer.java (UTF-8)
 *
 * Interface for OO purposes
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.4
 * @version 1.0.7
 */
public interface WordRenderer {

    public void render(String word, BufferedImage image);
}
```

Listing A.71: captchabuilder.util.enums.producer.BackgroundProducerType

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
```

```
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums
    .producer;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background.BackgroundProducer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.background.BackgroundProducerBuilder;

/**
 * BackgroundProducerType.java (UTF-8)
 *
 * all types of background producers
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.4
 * @version 1.0.13
 */
public enum BackgroundProducerType {
    FLATCOLOR("Creates a background in a single color"),
    SQUIGGLES("Creates a squiggly background"),
    TRANSPARENT("Creates a transparent background"),
    TWOCOLORGRADIENT("Creates a two color horizontal gradient background");
    private String description;

    private BackgroundProducerType(String description) {
        this.description = description;
    }

    /**
     * returns the description.
     * @return string description
     */
    public String getDescription() {
        return description;
    }

    /**
     * returns a producer of the type.
     *
     * @return a background producer
     * @see BackgroundProducer
     */
    public BackgroundProducer getBackgroundProducer() {
        return new BackgroundProducerBuilder(this).create();
    }
}
```

Listing A.72: captchabuilder.util.enums.producer.BorderProducerType

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
```

```
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums
    .producer;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.border.BorderProducer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.border.BorderProducerBuilder;

/**
 * BorderProducerType.java (UTF-8)
 *
 * all types of border producers
 *
 * 2013/04/18
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.12
 * @version 1.0.13
 */
public enum BorderProducerType {
    SOLID("Creates a solid border");
    private String description;

    private BorderProducerType(String description) {
        this.description = description;
    }

    /**
     * returns the description.
     * @return string description
     */
    public String getDescription() {
        return description;
    }
```

```
    /**
     * returns a producer of the type.
     *
     * @return a border producer
     * @see BorderProducer
     */
    public BorderProducer getBorderProducer() {
        return new BorderProducerBuilder(this).create();
    }
}
```

Listing A.73: captchabuilder.util.enums.producer.NoiseProducerType

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */

package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums
    .producer;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise.NoiseProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.noise.NoiseProducer;

/**
 * NoiseProducerType.java (UTF-8)
 *
 * all types of noise producers
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
```

```
 * @author Hogent StudentID <2000901295>
 * @since 1.0.5
 * @version 1.0.13
 */
public enum NoiseProducerType {
    CURVEDLINE("creates a curved line on the image to serve as noise"),
    STRAIGHTLINE("creates a straight line on the image to serve as noise");
    private String description;

    private NoiseProducerType(String description) {
        this.description = description;
    }

    /**
     * returns the description.
     * @return string description
     */
    public String getDescription() {
        return description;
    }

    /**
     * returns a producer of the type.
     *
     * @return a noise producer
     * @see NoiseProducer
     */
    public NoiseProducer getNoiseProducer() {
        return new NoiseProducerBuilder(this).create();
    }
}
```

Listing A.74: captchabuilder.util.enums.producer.TextProducerType

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
```

```
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums
    .producer;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text.TextProducerBuilder;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.producer.text.TextProducer;

/**
 * TextProducerType.java (UTF-8)
 *
 * all types of text producers
 *
 * 2013/04/14
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.1
 * @version 1.0.13
 */
public enum TextProducerType {

    ALPHANUMERIC("Generates alphanumeric strings"),
    REDUCED_ALPHANUMERIC("Generates reduced alphanumeric characterset
        strings to prevent ambiguities"),
    CHINESE("Generates Chinese character strings"),
    ARABIC("Generates Chinese character strings"),
    NUMBERS("Generates number strings"),
    LETTERS("Generates normal character strings"),
    LETTERS_SPECIAL("Generates normal character combined with special
        character strings"),
    NUMBERS_SPECIAL("Generates number strings combined with special
        character strings"),
    ALPHANUMERIC_SPECIAL("Generates alphanumeric strings combined with
        special character strings");
    private String desciption;

    private TextProducerType(String desciption) {
        this.desciption = desciption;
    }

    /**
     * returns the description.
     * @return string description
     */
    public TextProducer getTextProducer() {
        return new TextProducerBuilder(this).create();
    }

    /**
     * returns a producer of the type.
     *
     * @return a text producer
     * @see TextProducer
     */
    public String getDescription() {
        return desciption;
    }
```

```
    @Override
    public String toString() {
        return name() + ": " + desciption;
    }
}
```

Listing A.75: captchabuilder.util.enums.renderer.GimpyRendererType

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
     copy
 * of this software and associated documentation files (the "Software"), to
     deal
 * in the Software without restriction, including without limitation the
     rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
     in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
     OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
     THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums
    .renderer;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy.GimpyRenderer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.gimpy.GimpyRendererBuilder;



/**
 * GimpyRendererType.java (UTF-8)
 *
 * all types of Gimpy renderers
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.3
 * @version 1.0.13
```

```
 */
public enum GimpyRendererType {
    BLOCK("Description: block"),
    DROPSHADOW("Description: dropshadow"),
    FISHEYE("Description: fish eye"),
    RIPPLE("Description: ripple"),
    SHEAR("Description: shear"),
    STRETCH("Description: stretch");
    private String description;

    private GimpyRendererType(String description) {
        this.description = description;
    }

    /**
     * returns the description.
     * @return string description
     */
    public String getDescription() {
        return description;
    }

    /**
     * returns a renderer of the type.
     *
     * @return a gimpy renderer
     * @see GimpyRenderer
     */
    public GimpyRenderer getGimpyRenderer() {
        return new GimpyRendererBuilder(this).create();
    }
}
```

Listing A.76: captchabuilder.util.enums.renderer.WordRendererType

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
```

```
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
     FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.util.enums
    .renderer;

import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text.WordRenderer;
import be.hogent.pietervaneeckhout.bachelorthesis.captchabuilder.
    elementcreator.renderer.text.WordRendererBuilder;


/**
 * WordRendererType.java (UTF-8)
 *
 * all types of Word renderers
 *
 * 2013/04/16
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.3
 * @version 1.0.13
 */
public enum WordRendererType {

    COLOREDEDGES("Description"),
    DEFAULT("The default word renderer");
    private String desciption;

    private WordRendererType(String desciption) {
        this.desciption = desciption;
    }

    /**
     * returns the description.
     * @return string description
     */
    public WordRenderer getWordRenderer() {
        return new WordRendererBuilder(this).create();
    }

    /**
     * returns a renderer of the type.
     *
     * @return a word renderer
     * @see WordRenderer
     */
    public String getDescription() {
        return desciption;
    }

    @Override
    public String toString() {
        return name() + ": " + desciption;
    }
}
```

Listing A.77: neuralnetworks.network.encog.util.PropagationType

```
/*
 * The MIT License
 *
 * Copyright 2013 Pieter Van Eeckhout.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a
    copy
 * of this software and associated documentation files (the "Software"), to
    deal
 * in the Software without restriction, including without limitation the
    rights
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included
    in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
    OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL
    THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
    FROM,
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
 * THE SOFTWARE.
 */
package be.hogent.pietervaneeckhout.bachelorthesis.neuralnetworks.network.
    encog.util;

/**
 * PropagationType.java (UTF-8)
 *
 * usage and functionality here
 *
 * 2013/05/19
 *
 * @author Pieter Van Eeckhout <vaneeckhout.pieter@gmail.com>
 * @author Pieter Van Eeckhout <pieter.vaneeckhout.q1295@student.hogent.be>
 * @author Hogent StudentID <2000901295>
 * @since 1.0.0
 * @version 1.0.0
 */
public enum PropagationType {

    Backpropagation,
    ManhattanPropagation,
    ResilientPropagation,
    ScaledConjugateGradient;
}
```

List of Figures

List of Tables

Listings