Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

A computer-based learning environment aimed for students at the 3rd and 4th grade level

Bachelor's Thesis

Florian Bütler
flbuetle@ethz.ch

Chair of Information Technology and Education
ETH Zürich

Supervisor:
Prof. Juraj Hromkovič

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Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Eigenständigkeitserklärung

Die unterzeichnete Eigenständigkeitserklärung ist Bestandteil jeder während des Studiums verfassten Semester-, Bachelor- und Master-Arbeit oder anderen Abschlussarbeit (auch der jeweils elektronischen Version).

Die Dozentinnen und Dozenten können auch für andere bei ihnen verfasste schriftliche Arbeiten eine Eigenständigkeitserklärung verlangen.

Ich bestätige, die vorliegende Arbeit selbständig und in eigenen Worten verfasst zu haben. Davon ausgenommen sind sprachliche und inhaltliche Korrekturvorschläge durch die Betreuer und Betreuerinnen der Arbeit.

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Ich bestätige mit meiner Unterschrift:
- Ich habe keine im Merkblatt „Zitier-Knigge“ beschriebene Form des Plagiats begangen.
- Ich habe alle Methoden, Daten und Arbeitsabläufe wahrheitsgetreu dokumentiert.
- Ich habe keine Daten manipuliert.
- Ich habe alle Personen erwähnt, welche die Arbeit wesentlich unterstützt haben.

Ich nehme zur Kenntnis, dass die Arbeit mit elektronischen Hilfsmitteln auf Plagiate überprüft werden kann.

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Acknowledgements

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Abstract

a brief introduction describing the discipline that the paper belongs to a clear and concise statement of your problem a brief explanation of your solution and its key ideas a brief description of the results obtained and their impacts

Contents

Chapter 1

Introduction

With the introduction of Lehrplan 21 Computer Science became an integral part of the Swiss education curriculum [1]. Pupils learn to understand the basic concepts of Computer Science and how to use them for problem solving. These concepts include methods on how to process, evaluate and summarize data, how to securely communicate and how to develop solution strategies for simple problems of information processing [2]. The Education and Counselling Center for Computer Science Education at ETH Zurich (ABZ) supports schools to teach these concepts among others by providing teaching resources and learning environments.

The main goal in this bachelor thesis is to implement tasks and riddles based on the textbook "einfach Informatik 3/4" in a computer-based learning environment that teaches the following concepts:

- representing information with symbols,
- protecting data and keeping information secret and
- learning from data

for pupils in the second cycle. Along with solving tasks and riddles about the mentioned topics the ability of reading, writing, counting and calculating is trained as well.

This report first explains how the aforementioned concepts are thought by hands-on exercises, then gives in-depth technical insight on how a learning environment is developed and how these exercises are implemented. Finally, the report ends with a conclusion with a review of the project.

Todo: related work: abz.inf.ethz.ch other learning environments

Chapter 2

Concepts

This chapter is split into three parts. Each part discusses a basic concept of Computer Science and its corresponding exercises.

2.1 Representing Information with Symbols

Representing information with symbols is a fundamental concept of Computer Science as information should be represented clear and concisely. Words can be seen as a sequence of symbols, namely a sequence of letters.

2.1.1 Similar Words

Transmitting information includes representing it in a message, sending it to the destination and the receiver being able to make sense of it even tough the message might contain errors such as a spelling mistake. To achieve this sender and receiver agree to only send messages with a minimal editing distance [3] between each of them.

The editing distance is the amount of operations that need to be done to transform a message in another. Operations are deleting, inserting and changing a letter . A cost function exists that defines the cost of each operation, and in our case each operation has a cost of 1 (unit cost model). The editing distance is then the minimal cost to transform a message into another one by a sequence of operations. In our case a message is a word.

Todo: add some TI explanation

Example 2.1. The editing distance between `like` and `bike` is 1, since changing the first letter from an `l` to and `b` transforms the first word into the second.

If sender and receiver agree to only transmit words with a minimal editing distance of e.g 3, then the receiver can still uniquely determine what word the sender has sent even when at most 1 spelling mistake has been made. The receiver calculates the minimal editing distance between the received word and each of

the agreed words and chooses the word with the least editing distance. The receiver assume that this was the word the sender wanted to sent. This of course work only if there are not more than 1 error in the word. If this happens the editing distance to another word is closer than to the original word and hence the word is misinterpreted. To counter this, sender and receiver might agree on a bigger minimal distance, but this comes with a tradeoff. When chosing a bigger minimal distance for a fixed alphabet, the number of words we can use shrinks. To maintain the same amount of words we can choose to increase the size of the alphabet as well, resulting in longer words.

The purpose of the `similar words` exercises is to learn these operations. Therefore we have an exercise dedicated to each opertion: adding, changing and

2.1.2 Representing Numbers like the Maya

2.1.3 Representing Numbers with Coins

2.1.4 Representing Numbers with Binary Coins

2.2 Protecting Data and Keeping Information Secret

2.2.1 Cipher Texts from Reversed Letters

2.2.2 Cipher Texts from New Characters

2.3 Learning from Data

2.3.1 Row of Trees

2.3.2 Tree Sudoku

Chapter 3

Implementation

Chapter 4

Conclusion

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further work: integrate into existing learning environment drawbacks: not all exercises per topic, own learning environment

Bibliography

[1] Lehrplan 21. Accessed on 01.02.2021. [Online]. Available: https://lehrplan21.ch

[2] Medien und informatik. Accessed on 01.02.2021. [Online]. Available: https://www.regionalkonferenzen.ch/medien-und-informatik

[3] P. W. Thomas Ottmann, *Algorithmen und Datenstrukturen.* Spektrum, 2012.

Appendix A

First Chapter Title

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Todo: This is a TODO annotation.

A.1 First Section Title

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A.1.1 First Subsection Title

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Remark: This is a REMARK annotation.

Theorem A.1 (First Theorem)**.** *This is our first theorem.*

Proof. And this is the proof of the first theorem with a complicated formula and a reference to Theorem A.1. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua.

$$\frac{\mathrm{d}}{\mathrm{d}x}\arctan(\sin(x^2)) = -2 \cdot \frac{\cos(x^2)x}{-2 + (\cos(x^2))^2} \tag{A.1}$$

□

Lemma A.2. *lorem ipsum dolor sit amet*

Corollary A.3. *lorem ipsum dolor sit amet*

Observation A.4. *lorem ipsum dolor sit amet*

Figure A.1: This is an example graphic.

Definition A.5. lorem ipsum dolor sit amet

Problem A.6. lorem ipsum dolor sit amet

Assumption A.7. lorem ipsum dolor sit amet

Example A.8. lorem ipsum dolor sit amet

Claim A.9. lorem ipsum dolor sit amet

Remark A.10. lorem ipsum dolor sit amet

An example of an included graphic can be found in Figure A.1. Note that in LaTeX, "quotes" do not use the usual double quote characters.