Literate Programming Report

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Abstract

roadnet is a Ruby based compiler for converting an XML description of a road network into an HTML/SVG visual representation. This document outlines the methodology, languages and frameworks used, as well as implenetation and testing steps.

1 Summary

roadnet is the name given to a tool which allows for the generation of simple graphical road networks using a specially developed road topology language. This tool converts an XML file containing the hierarchy of the road network into an HTML page displaying the network from a bird's-eye viewpoint, using SVG drawings. Three different road types are supported, including a two-lane road, a local street, and a four lane avenue. Road length, intersection radius, and intersecting angle offsets are the parameters that are specifiable, in addition to the structure of the network, via the XML file.

1.1 Problem Inspiration

The inspiration for the tool stems from a pass-time I once cherished as a child. I would often spend hours sketching small neighbourhoods onto a large piece of drafting paper. Attention to detail was especially evident in how I drew the roads; from a bird's eye perspective, lane widths were meticulously calculated and enforced with a ruler through the entirety of my drawings.

Attempting to bring rekindle that hobby and bring it into the digital world is the motivation for such a tool. While of no practical purpose for transportation engineers, it offers an academic and practical insight into the fundamentals of compiler design with recursion, using a modern high-level language.

2 Languges & Tools

The compiler transforms an XML file into an HTML file with embedded SVG graphics. XML was chosen as the source because it allows one the freedom to write nested hierarchies with tags that describe attributes. This is important given that a road topology is a network of elements that are often repeated and are always connected to one another. An XML file assures that each element has a parent, just like each segment of road generally intersects with another.

SVG within HTML is used as the output representation because it is a very widely available and performant markup language which is compatible across platforms. Using SVG, **roadnet** is able to easily create paths that represent lane markings, road edges, and intersections.

The program is written in Ruby in order to take advantage of the excellent Nokogiri gem which makes the task of parsing elements in XML and HTML files a breeze. In the implementation, Nokogiri parses the XML file recursively, drawing the appropriate paths in SVG as it descends the parse tree.

3 Resources

Various resources were consulted over the course of the development of the tool.

Resources consulted over the course of the project:

- **General inspiration:** http://programmers.stackexchange.com/questions/165543/how-to-write-a-very-basic-compiler
- **Nokogiri docs:** https://github.com/sparklemotion/nokogiri
- **Nokogiri cheatsheet:** https://github.com/sparklemotion/nokogiri/wiki/Cheat-sheet
- **SVG primer:** http://www.w3schools.com/svg/svg_examples.asp
- **LaTeX information:** https://en.wikibooks.org/wiki/LaTeX
- **NoWeb literature:** http://www.literateprogramming.com/noweb_hacker.pdf

4 Implementation

4.1 Getting Started

Running **roadnet** is very simple. In the directory where parser.rb is found, simply execute the following command:

```
$ ruby parser.rb -f rd.xml
```

.

The -f command line option is necessary - it specifies the road topology xml file. An -o flag is optional, it specifies the output file. The default output file is diagram.html

4.2 The XML Source

The XML file must have exactly one ⟨network⟩ root tag, followed by any number of nested structures comprising of ⟨road⟩, ⟨avenue⟩, or ⟨street⟩ tags. Including other tags will raise an error. A parent tag of child elements suggests that the child elements are connected via an intersection to the end of the parent tag.

There are four specifiable attributes. The *intersection-offset* and *intersection-radius* are intersection level attributes, and specify properties pertaining to an intersection, while the *length* attribute and *angle-offset* specify properties of a network link (be it a road, street, or avenue). *intersection-offset* is specified in degrees, and rotates the intersection and all jutting links by x degrees. *intersection-radius* specified in pixels, dicates the radius an intersection. *angle-offset* rotates the specific link on which it is called x degrees clockwise. *length* is self explanatory, its dimensions are in pixels.

Here is an example XML file illustrating the abovementioned properties:

```
<?xml version="1.0" encoding="UTF-8"?>

<network intersection-radius="100">
        <avenue>
        </avenue>
        <road intersection-offset="180" angle-offset="-20" intersection-radius
            ↪ ="20">
```

```
                <road>
                </road>
                <street>
                </street>
        </road>
        <road>
        </road>
        <road>
                <street>
                </street>
                <street length="400" >
                        <road>
                        </road>
                        <road>
                        </road>
                        </street>
                <street>
                </street>
        </road>
        <street>
        </street>
</network>
```

.

Due to the recursive tree-like structure of the XML file, no cycles are permitted in the road network. That is, a nested link cannot connect with with another beyond its immediate siblings. In other words, the set forms a minimum spanning tree, and is divergent, rather than convergent.

4.3 Ruby Program

There are three dependencies that must be installed using a tool such as **bundler** before running the program. These dependencies include **nokogiri**, **optparse**, and **solid_assert**.

The below code executes the option parser which looks for the command line arguments specifying the input xml file, and an optional output html file. If the input file is missing, or there are abnormal command line arguments, and error is thrown and the program is aborted.

```
#!/usr/bin/env ruby

require 'rubygems'
require 'bundler/setup'

require 'nokogiri'
require 'optparse'
require 'solid_assert'

SolidAssert.enable_assertions

options = {}

optparse = OptionParser.new do |opts|
        opts.banner = "Usage: parser.rb -f <xml filename> [ -o <output
            filename> ]"
```

```
        opts.on('-f', '-x', '--xml_input-filename', 'XML file name') { |v|
            ↪ options[:filename] = v }
        opts.on('-o', '-h', '--html_output-filename', 'HTML file name') { |v|
            ↪ options[:output] = v }
end

begin
        optparse.parse!
        mandatory = [:filename]
        missing = mandatory.select{ |param| options[param].nil? }
        unless missing.empty?
                puts "Missing options: #{missing.join(', ')}"
                puts optparse
                exit
        end
rescue OptionParser::InvalidOption, OptionParser::MissingArgument
        puts $!.to_s # Friendly output when parsing fails
        puts optparse
        exit
end
```

.

The next section of code opens the XML for parsing using Nokogiri, a parsing library for HTML and XML files. It sets strict options on the file, mandating a well-formed XML file that is free of errors. If errors are detected, the program aborts.

Several constants are also set in this part of the program. Notice that these variables begin with an ampersand - this is Ruby's way of telling the user that these variables have a global scope.

```
begin
        @xml = Nokogiri::XML(File.open(options[:filename])) do |config|
                config.options = Nokogiri::XML::ParseOptions::STRICT |
                    ↪ Nokogiri::XML::ParseOptions::NONET
        end
rescue Nokogiri::XML::SyntaxError => e
        puts "caught exception: #{e}"
end

begin assert @xml.root.name == "network" rescue abort "Ensure that the <
    ↪ network> tag is at the root" end

#Constants
@default_length = 200
@lane_width = 20
@intersection_radius = 50
```

.

The next section is the most important - it comprises the bulk of the program's logic - the recursive function definition. In *draw_intersection(node, html, cx, cy)*, paths are created in an html object passed into the function. *node* is the current "intersection" being drawn, and changes based on the context of execution (parent vs child elements). *cx and cy* are the origin co-ordinates of the interesection.

The function begins by setting up some arrays, which are used for keeping track of the total size taken up by the SVG objects. An angle is computed based on the number of children nodes that will spawn off from the intersection. Other specifiable attributes are initialized next. Finally, we reach a loop structure which iterates over the child elements. Different numbers of lines are drawn depending on the road type. At the bottom, the width and height calculations of the bounding frame are made based on the results from the recursive calls to the child elements.

```ruby
def draw_intersection(node, html, cx, cy)

        width_arr = Array.new
        height_arr = Array.new

        max_width = 0
        max_height = 0
        min_width = 0
        min_height = 0

        angle = 2*Math::PI / node.elements.size

        angle_offset = node.key?("angle-offset") ? (node.attribute("angle-offset").value.to_f)*Math::PI/180 : 0

        intersection_offset = node.key?("intersection-offset") ? (node.attribute("intersection-offset").value.to_f)*Math::PI/180 : 0

        intersection_radius = node.key?("intersection-radius") ? (node.attribute("intersection-radius").value.to_f) : @intersection_radius

        html.circle(:cx => cx, :cy => cy, :r => intersection_radius, :stroke => "red", :fill => "white")

        node.elements.each_with_index do |node, index|

                length = node.key?("length") ? (node.attribute("length").value.to_f) : @default_length

                ang = (angle + angle_offset)*index + intersection_offset
                x_dist = Math.cos(ang)*length
                y_dist = Math.sin(ang)*length

                x_radius = Math.cos(ang)*intersection_radius
                y_radius = Math.sin(ang)*intersection_radius

                x_start = cx + intersection_radius*Math.cos(ang)
                y_start = cy + intersection_radius*Math.sin(ang)

                if node.name == "road"
                        #draw three lines

                        x_start_1 = x_start + @lane_width*Math.cos(ang - Math::PI/2)
                        x_start_2 = x_start + @lane_width*Math.cos(ang + Math::PI/2)
```

```
            y_start_1 = y_start + @lane_width*Math.sin(ang - Math
              ↪ ::PI/2)
            y_start_2 = y_start + @lane_width*Math.sin(ang + Math
              ↪ ::PI/2)

            html.line(:x1 => x_start_1, :x2 => x_start_1+x_dist, :
              ↪ y1 => y_start_1, :y2 => y_start_1+y_dist)
            html.line.dashed(:x1 => x_start, :x2 => x_start+x_dist
              ↪ , :y1 => y_start, :y2 => y_start+y_dist)
            html.line(:x1 => x_start_2, :x2 => x_start_2+x_dist, :
              ↪ y1 => y_start_2, :y2 => y_start_2+y_dist)

      elsif node.name == "avenue"
            #draw five lines

            x_start_1 = x_start + 2*@lane_width*Math.cos(ang -
              ↪ Math::PI/2)
            x_start_2 = x_start + @lane_width*Math.cos(ang - Math
              ↪ ::PI/2)
            x_start_3 = x_start + @lane_width*Math.cos(ang + Math
              ↪ ::PI/2)
            x_start_4 = x_start + 2*@lane_width*Math.cos(ang +
              ↪ Math::PI/2)

            y_start_1 = y_start + 2*@lane_width*Math.sin(ang -
              ↪ Math::PI/2)
            y_start_2 = y_start + @lane_width*Math.sin(ang - Math
              ↪ ::PI/2)
            y_start_3 = y_start + @lane_width*Math.sin(ang + Math
              ↪ ::PI/2)
            y_start_4 = y_start + 2*@lane_width*Math.sin(ang +
              ↪ Math::PI/2)

            html.line(:x1 => x_start_1, :x2 => x_start_1+x_dist, :
              ↪ y1 => y_start_1, :y2 => y_start_1+y_dist)
            html.line.dashed(:x1 => x_start_2, :x2 => x_start_2+
              ↪ x_dist, :y1 => y_start_2, :y2 => y_start_2+
              ↪ y_dist)
            html.line(:x1 => x_start, :x2 => x_start+x_dist, :y1
              ↪ => y_start, :y2 => y_start+y_dist)
            html.line.dashed(:x1 => x_start_3, :x2 => x_start_3+
              ↪ x_dist, :y1 => y_start_3, :y2 => y_start_3+
              ↪ y_dist)
            html.line(:x1 => x_start_4, :x2 => x_start_4+x_dist, :
              ↪ y1 => y_start_4, :y2 => y_start_4+y_dist)

      elsif node.name == "street"
            #draw two lines

            x_start_1 = x_start + 0.8*@lane_width*Math.cos(ang -
              ↪ Math::PI/2)
            x_start_2 = x_start + 0.8*@lane_width*Math.cos(ang +
              ↪ Math::PI/2)
```

```
                        y_start_1 = y_start + 0.8*@lane_width*Math.sin(ang - Math::PI/2)
                        y_start_2 = y_start + 0.8*@lane_width*Math.sin(ang + Math::PI/2)

                        html.line(:x1 => x_start_1, :x2 => x_start_1+x_dist, :y1 => y_start_1, :y2 => y_start_1+y_dist)
                        html.line(:x1 => x_start_2, :x2 => x_start_2+x_dist, :y1 => y_start_2, :y2 => y_start_2+y_dist)

                else
                        abort "Invalid type in XML"

                end

                width_arr << x_start + x_dist + 2*x_radius
                height_arr << y_start + y_dist + 2*y_radius

                max_width, min_width, max_height, min_height = draw_intersection(node, html, x_start+x_dist, y_start+y_dist)

                width_arr << max_width
                width_arr << min_width
                height_arr << max_height
                height_arr << min_height

                max_width = width_arr.max
                min_width = width_arr.min
                max_height = height_arr.max
                min_height = height_arr.min

        end

        return max_width, min_width, max_height, min_height
end
```

.

The mysterious *html* argument to the previous function is unveiled here. Nokogiri has a builder method which allows for the easy creation of an HTML file. The structural elements are defined here, and the recursive function is initialized to operate on the root XML element, starting at the 0, 0 position.

```
builder = Nokogiri::HTML::Builder.new do |html|
        html.html {
                html.head {
                        html.style "svg { border: 2px solid black; } line { stroke: rgb(255,0,0); stroke-width:2 } .dashed { stroke-dasharray: 10, 10 }"
                }
                html.body {
                        html.h1.title "Roadnet: XML to SVG road networks converter"
                        html.svg {
                                html.g {
```

```
                                                @max_width, @min_width, @max_height,
                                                    ↪ @min_height = draw_intersection(
                                                    ↪ @xml.root, html, 0, 0)
                                        }
                                }
                        }
                }
end
```

.

Lastly, the entire SVG graphic group (denoted by html.g) is shifted so that it all fits within the SVG bounding box. It is given a height and width that closely wraps the edges of all the lements within the graphic.

Finally, the HTML file is writte either to the default filename, or to the one specified on the command line, if applicable.

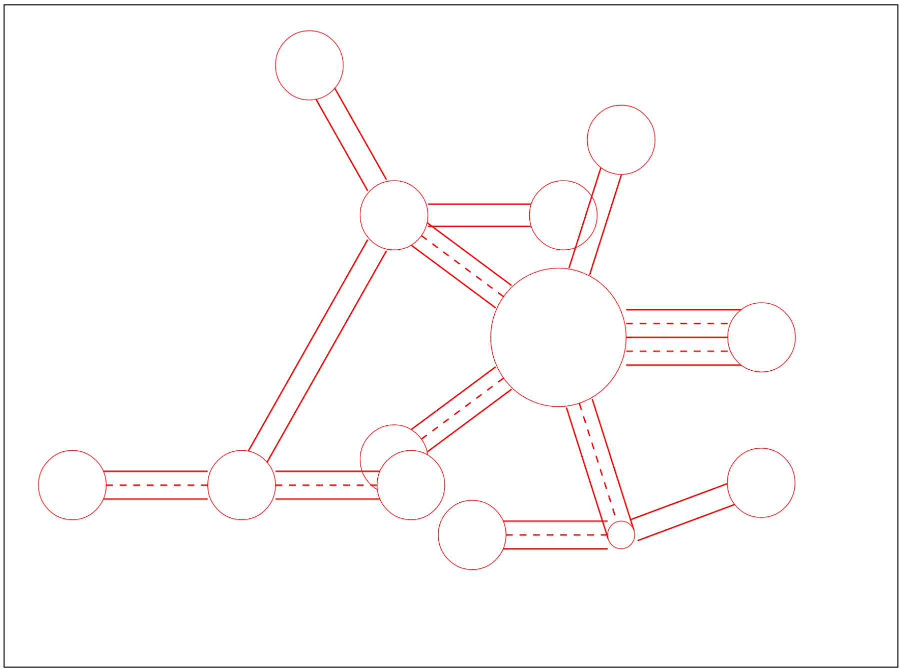
```
@width = @max_width - @min_width
@height = @max_height - @min_height

@html = Nokogiri::HTML::DocumentFragment.parse builder.to_html
@html.at_css("svg")["width"] = @width
@html.at_css("svg")["height"] = @height
@html.at_css("g")["style"] = "transform: translate(" + (-@min_width).to_s + "
    ↪ px, " + (-@min_height).to_s + "px)"

if options[:output] == nil then
        File.write('diagram.html', @html)
else
        File.write(options[:output], @html)
end
```

.

4.4 HTML Output

The HTML SVG file output is quite ugly. It's composed of many SVG circles and lines in one SVG group. A screenshot has been provided below based off of the XML input file described earlier in the report:

Roadnet: XML to SVG road networks converter



5 Testing & Validation

Testing was completed simply by trying different combinations of xml tags in the XML input file, and verifying that the output looked sane. Malformed XML, as well as non-accepting XML tags and attributes were added, and the output was verified to show an error message in all cases.

6 Future Considerations

The original plan was to draw the intersections such that no overlapping paths would exist. Because of time constraints and technical difficulties involving the storage and retrieval of x and y coordinates pushed onto a stack and then popped, this wasn't done. For the future, a nice feature would be to add Bezier curves to link each road link within an intersection to eachother, as in a real top-down view of a road network. SVG has native support for Bezier curves.

7 A note on noweb

Despite one of the major learning points of this project being the assimilation of a literate programming tool, (in my case *noweb* was researched), I would like to state why I have not used it and provide arguments in favour of a more modern approach.

noweb was conceived almost 30 years ago, shortly after Knuth's WEB appeared in computer science journals and made a small impact in the computer science community. Being a novel idea, it was hailed by many as a programming paradigm that would solve the perennial problem of not having enough comments in code, or of comment quality not being up to par.

It does accomplish those goals to a reasonable degree, as it forces the programmer to write out the logic and control flow of his/her program in natural language before writing any computer code. It also strives to create a single document which comprises both the code and the documentation in a portable format, which can be ”weaved” into a documentation only file, or ”tangled” into the resulting high-level computer code.

This approach is no longer relevant in today’s world because the way we document and write code has changed significantly since the time this was introduced. For starters, the Internet has revolutionized the way we access information about programming languages and any errors encountered using them. Gone or the days of sifting through manuals to find API calls or language specific constructs. Suffice it to perform a Google Search and have all this information at our fingertips. With literate programming, documentation is not presented in an easily accessible format and therefore cannot take advantage the Interenet’s ability to find information easily.

Next, while noweb is supposedly language agnostic, in that a .nw file can be ”tangled” into any high level language, there are still certain ”reserved” characters that must be excaped before this transformation can happen. In the Ruby program described above, the ”⟨⟨” character is a noweb reserved construct, and because of this, several errors were raised when trying to ”weave” or ”tangle” the document into any sort of output. There are supposed escape characters that can be applied to mitigate this, however I firmly believe that any tool which requires modification of the source code to appease a documentation compiler is a poorly designed one.

Finally, there is the argument of natural language being ambiguous, and not suited to describe programming constructs. Natural language within code can be good, but only when it augments what is already evident by the code. Literate programming seems to me like nailing two blocks of wood super glued together. The nails are unecessary, as the super glue already accurately holds together the wood. The same can be said of code with good comments which fill in missing gaps of information, rather than pre-describe everything the code does at a natural language level.

The fact that literate programming is so rarely used, epecially in the practical, non-academic world should be the indicator to many that the last nail is already in the coffin - it’s time to retire the notion of literate programming as a viable tool.