Getting started: a tutorial to Animate++

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Installation

Dependencies

- C++17
- clang: macOS version

```
clang version 6.0.0 (tags/RELEASE_600/final)
```

- ar: UNIX command line tool
- boost is utilized in our project. To download boost, simply run `brew install boost` on MacOS or download boost from the this link if you are a Windows or Linux user.
  - Tested version: `1.66.0`
- pugi is the xml parser which supports all parsing tasks, helping us extract content from SVG files. Tutorial on downloading pugi can be followed through this link. After library being downloaded, put the whole unzipped file under the same directory as the code files, and you are ready to go.
  - Tested version: `1.9`

Getting started

- To build the project: type `make`
  - compiles the library and archives it using `ar`
  - generates `libAnipp.a` in `build` directory
- To build tests: type `make test`
  - generates a binary called `test-driver` in `build` directory
  - run `./build/test-driver` to run all the tests
  - all outputs of the tests are contained in `test/output`
- To build an `tar` file that contains all headers and the library archive to use Animate++ elsewhere, type `make release`, which generates a tar file in same directory.
  - To use the library, you need to have `boost` on your machine
  - To compile a test file that calls functions from Animate++, suppose we have a test file `main.cpp`

```cpp
#include "animate.hpp"
#include <iostream>
int main() {
    anipp::Circle c(10, 10,1);
    std::cout << c << '\n';
}
```

  - You can write a Makefile or just use the following commands to compile `main.cpp` (assuming `boost` is located at `/usr/local/Cellar/boost/1.66.0/`).

```
$ g++ -c main.cpp -o main.o  -I./src -I./include/pugixml-1.9/src
-I/usr/local/Cellar/boost/1.66.0/include  -std=c++1z

$ g++ main.o -o main -I./src  -I/usr/local/Cellar/boost/1.66.0/include
-L/usr/local/Cellar/boost/1.66.0/lib -lboost_regex-mt -L. -lAnipp
```

  - If you have a newer version of Clang, please use `std=c++17` instead of `std=c++1z`.

Creating Basic shapes

1. Rectangle

- In SVG, rectangle is called using `<rect>`.
  Within the scope of `<rect>`, we need to define 4 major properties to at least make the shape valid:
  x : x-coordinate of top left corner
  y : y-coordinate of top left corner
  width : width of rectangle
  height : height of rectangle
- An example shown in below as:
  `<rect x="10" y="10" width="30" height="30"/>`
  Our c++ initialization is:

```
Rect r(10, 10, 30, 30);
```

2. Circle

- In SVG, rectangle is called using `<circle>`.
  Within the scope of `<rect>`, we need to define 3 major properties to at least make the shape valid:
  cx : center coordinate on x-axis
  cy : center coordinate on y-axis
  r : radius
- An example shown in below as:
  `<circle cx="25" cy="75" r="20"/>`
  Our c++ initialization is:

```
Circle c(25, 75, 20);
```

3. Ellipse

- In SVG, ellipse is called using `<ellipse>`.
  Within the scope of `<ellipse>`, we need to define 4 major properties to at least make the shape valid:
  cx : center coordinate on x-axis
  cy : center coordinate on y-axis
  rx : radius on x-axis
  ry : radius on y-axis
- An example shown in below as:
  `<ellipse cx="75" cy="75" rx="20" ry="5"/>`
  Our c++ initialization is:

```
Ellipse e(75, 75, 20, 5);
```

4. Line

- In SVG, line is called using `<line>`.
  Within the scope of `<line>`, we need to define 4 major properties to at least make the shape valid:
  x1 : starting x-axis coordinate
  x2 : ending x-axis coordinate
  y1 : starting y-axis coordinate
  y2 : ending y-axis coordinate
- An example shown in below as:
  `<line x1="10" x2="50" y1="110" y2="150"/>`
  Our c++ initialization is:

```
Line l(10, 50, 110, 150);
```

5. Polyline

- In SVG, polyline is called using `<polyline>`.
  Within the scope of `<polyline>`, we need to define a list of points, simply an array of pairs of numbers.
- An example shown in below as:
  `<polyline points="60 110 65 120"/>`
  Our c++ initialization is:

```
Vector<Point> vec(Point(60, 110), Point(65, 120));
Polyline p(vec);
```

6. Polygon

- In SVG, polygon is called using `<polygon>`.
  Within the scope of `<polygon>`, we need to define a list of points, simply an array of pairs of numbers.
- An example shown in below as:
  `<polygon points="50 160 55 180"/>`
  Our c++ initialization is:

```
Vector<Point> vec(Point(50, 160), Point(55, 180));
Polygon p(vec);
```

7. Path

- In SVG, path is called using `<path>`.
  Path is the fundamental building block to compose complicated shape among all SVG basic shapes, but it is what makes SVG powerful. There can be a large number of types of input paths and they end up to be all valid. Due to the large number of samples covered, we will not enumerate all of them in the following text (see our complete documentation for details). Our parser has covered most of the valid curve commands. Any valid curve command can be taken as a string input to our constructor.
- An example shown in below as:
  `<path d="M20,230 Q40,205 50,230 T90,230"/>`
  Our c++ initialization can be:

```
string d="M20,230 Q40,205 50,230 T90,230";
Path p(d);
```

- There are some more useful functions that can be used to build a `Path` object.

moveTo()

- move the path to a certain position without drawing.
- Taking three parameters in sequence.
  - double: x (destination position on x-axis)
  - double: y (destination position on y-axis)
  - bool: relative (whether move in relative form or absolute form)

```
p.moveTo(x, y, relative);
```

lineTo()

- move the path to a certain position drawing a straight line.
- Taking three parameters in sequence.
  - double: x (destination position on x-axis)
  - double: y (destination position on y-axis)
  - bool: relative (whether move in relative form or absolute form)

```
p.lineTo(x, y, relative);
```

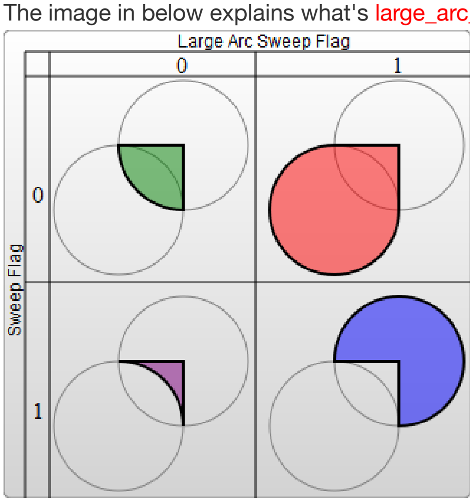
quadraticCurveTo()

- move the path to a position following a quadratic curve.
- Taking five parameters in sequence.
  - double: cpx (control point position on x-axis)
  - double: cpy (control point position on y-axis)
    - for more information about control points, click here
  - double: x (destination position on x-axis)
  - double: y (destination position on y-axis)
  - bool: relative (whether move in relative form or absolute form)

```
p.quadraticCurveTo(cpx, cpy, x, y, relative);
```

arcTo()

- move the path to a position following a arc, which can be treated as a smoother curve.
  bool relative
- Taking eight parameters in sequence.
  - double: rx (radius on x-axis)
  - double: ry (radius on y-axis)
  - double: x_axis_rotation (how much is the angle tilted)
  - double: large_arc_flag
  - double: sweep_flag
  - double: x (destination position on x-axis)
  - double: y (destination position on y-axis)
  - bool: relative (whether move in relative form or absolute form)
    The image in below explains what's large_arc_flag and what's sweep_flag




```
p.arcTo(rx, ry, x_axis_rotation, large_arc_flag, sweep_flag, x, y, relative);
```

cubicCurveTo()

Also known as bezier curve, which is the real soul of SVG!

- Taking seven parameters in sequence.
  - double: cp1x (control point 1 on x-axis)
  - double: cp1y (control point 1 on y-axis)
  - double: cp2x (control point 2 on x-axis)
  - double: cp2y (control point 2 on y-axis)
  - double: x (destination position on x-axis)
  - double: y (destination position on y-axis)
  - bool: relative (whether move in relative form or absolute form)

```
p.cubicCurveTo(cp1x, cp1y, cp2x, cp2y, x, y, relative);
```

Set external properties

Other than basic properties of each shape, there are more external properties, including color, stroke, etc. Animate++ supports easy ways for users to add properties.
The general way to set attribute is:

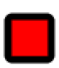
```
r.attr(string name, string value);
```

Given an example in below.
Before we set up stroke, fill and stroke-width:

`<rect x="10" y="10" width="30" height="30" stroke="black" fill="transparent" stroke-width="5"/>`
This is a rectangle with three external properties, stroke, fill and stroke-width.

```
r.attr({
        {"stroke", "black"},
        {"fill", "red"},
        {"stroke-width", "5"},
});
```

After setting up attributes, that's how it looks like.



We can simply modify the attributes to overwrite existing ones. For example:

```
r.attr({
        {"stroke", "black"},
        {"fill", "red"}
});
// now we reset fill color to yellow.
r.attr("fill", "yellow");
// Using same logic, we can delete existing attribute simply by setting it to empty string
r.attr("stroke", "");
```

Complex shapes

Of course, supporting only single type of object is not sufficient to accomplish all fancy functionalities that can potentially be achieved by SVGs. Animate++ also supports multiple shapes contained in one single file to be loaded all together.

```
// load in svg from a path, which is a string of local file directory
ShapePtr g = load(in_path);
// output the object to an SVG file
g->save(out_path);
```

Input and Output

Load directly from external SVGs

Other than creating users' own objects, one can simply load the object given relative path of the svg file, creating a ShapePtr object, which is simply a pointer to a Shape object.

```
string in_path = "sample.svg";
ShapePtr g = load(in_path);
```

Users can export the file simply by specifying the output directory, call save function.

```
string out_path = "output.svg";
g -> save(out_path);
```

Animation

In SVGs, objects can be animated, which are defined in tags such as `<animateTransform>` and, more generally, `<animate>`.
Animate++ also supports animation editing. Each shape object has an animator named animate. When user wants to edit the animation, simply call the `[object_name].animate.[function]` to set up the animation. Here are examples in detail.

Translation

In translation, user needs to define the initial and ending position on x and y axis. An example of translation is shown in below, from "100 100" to "0 200" entails that the object transforms from (100, 100) to (0, 200).

```
<animateTransform attributeName="transform" type="translate" dur="2.5s" from="100 100" repeatCount="indefinite" to="0 200" />
```

And that's how we use animate++ to rewrite the translation.

```
c.animate.translate(Point(100, 100), Point(0, 200))
         .duration("2.5s")
         .loop(true);
```


Or instead, given the amount an object is translated from current position instead of its destination using keyword by, which we referred to as relative translation. An example is shown in below.

```
<animateTransform attributeName="transform" type="translate" by="0 200" dur="2.5s" from="100 100" repeatCount="indefinite" />
```

This is also simple to achieve in animate++, for we only give a true boolean value as the third argument taken by translate function, which is by default false.

```
c.animate.translate(Point(100, 100), Point(0, 200), true)
         .duration("2.5s")
         .loop(true);
```

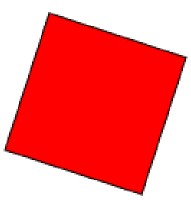
Rotation

In rotation, the from and to are in the form "n1 n2 n3", where "n1" entails the degree of rotation, and (n2, n3) indicates the center position of rotation. An example shown in below.

```
<animateTransform attributeName="transform"
        type="rotate" dur="10s" from="0 100 100"
        repeatCount="indefinite" to="360 100 100" />
```

That's how animate++ implements such rotation.

```
Point center(100, 100);
r.animate.rotate(center, 0, center, 360)
         .duration("10s")
         .loop(true);
```



Scaling

In scaling, the initial and ending scaling on x and y axis are both required. An example of scaling animation in SVG is shown in below, from "0 0" to "1 1" entails that the object's scale transforms from (0*x, 0*y) to (1*x, 1*y).

```
<animateTransform attributeName="transform"
        type="scale" dur="2.5s" from="0 0"
        repeatCount="indefinite" to="1 1" />
```

And that's how we use animate++ to rewrite the scaling.

```
c.animate.scale(Point(0, 0), Point(1, 1)) // from="0 0" to="1 1"
         .duration("2.5s") // dur="2.5s"
         .loop(true); // repeatCount="indefinite"
```

Move_along

In move_along, user asks the animate object of any shape to take an input from a Path object. The object will then have a motion along the path being created. An example in below shows how we can generate complicated SVG file using straightforward c++ code:

SVG file that generated from our c++ code.

```
<svg version="1.1" xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink">
<g id="group_1805">
        <path d="M 10 110 A 120 120 -45 0 1 110 10 A 120
                120 -45 0 1 10 110 " fill="none" stroke="lightgrey" stroke-width="2" id="path_1801" />
        <circle cx="10" cy="110" r="3" fill="lightgrey" id="circle_1802" />
        <circle cx="110" cy="10" r="3" fill="lightgrey" id="circle_1803" />
        <circle cx="0" cy="0" r="5" fill="red" id="circle_1804">
                <animateMotion dur="6s" repeatCount="indefinite">
                        <mpath xlink:href="#path_1801" />
                </animateMotion>
        </circle>
</g>
</svg>
```

Here is our C++ program that generates the SVG above:

```
// Define path that we will travel.
Path p;
p.moveTo(10, 110)
 .arcTo(120, 120, -45, 0, 1, 110, 10)
 .arcTo(120, 120, -45, 0, 1, 10,  110);
p.attr({
    {"stroke", "lightgrey"},
    {"stroke-width", "2"},
    {"fill", "none"},
});
// Create end point 1 on bottom left corner
Circle end_point1(10, 110, 3);
end_point1.attr("fill", "lightgrey");
// Create end point 2 on top right corner
Circle end_point2(110, 10, 3);
end_point2.attr("fill", "lightgrey");
// Create our red ball moving along the path
Circle ball(0, 0, 5);
ball.attr("fill", "red");
ball.animate.move_along(p)
            .duration("6s")
            .loop(true);

Group g(p, end_point1, end_point2, ball);
g.save(out_path);
```

Here comes the result.