A Tiktz Tutorial

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Introduction

What it this?

I am an upcoming third year (3A) student at the University of Waterloo who plans to take CO342 - Introduction to Graph Theory, in Fall 2019. To aid me and other students such as myself with typesetting graphs using tikz, I created this shortened tutorial from the TikZ and PGF Manual. Please do not hesitate to reach out to me if there are any errors and I will publish an updated version ASAP.

Goal

I have always believed in understanding your tools completely before using them. In addition to my tutorial on TikZ, I will include as much notes on the math behind non-trivial TikZ commands as I can, with the condition that I myself at least understand the gist of the technologies. If it is completey above me and looks like gobly goop, I will clearly note this and invite *you* to write me a short section based on your understanding.

1 Generic Setup

```
\documentclass{article}
\usepackage{tikz}
\usepackage{float}

\begin{document}
\begin{figure}[H] % forces position of tikz to be where it is in source file
    \centering

    \begin{tikzpicture}
        % insert provided code
    \end{tikzpicture}

    \caption{A Caption}
    \label{fig:alabel}
\end{figure}
\end{document}
```

This is our default setup for any document classes involving TikZ. If additional imports are necessary, we will explicityly note them.
Note that we may ommit typing “tikzpicture” everytime and inline simple TikZ pictures with the “tikz” command. When we do this, we will explicitly type out “tikz“.

2 Paths

2.1 Straight Paths

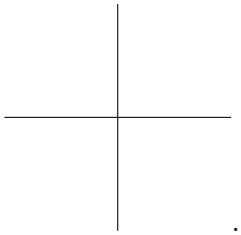

Figure 1: Basic Straight Path

```
\draw (-1.5,0) -- (1.5,0); % draw straight lines between two points
\draw (0,-1.5) -- (0,1.5);
```

We can also directly inline a similar picture

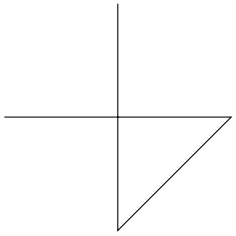

Figure 2: Inlined Straight Path

```
\tikz \draw (-1.5,0) -- (1.5,0) -- (0,-1.5) -- (0,1.5);
```

2.2 Curved Paths

TikZ allows us to define arbitrary curves using control points. The basis behind of this concept are Bézier Curves, which in turn are based on the Bernstein Polynomial.

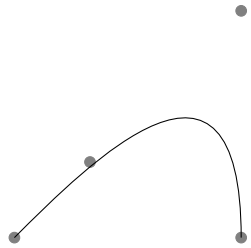

Figure 3: Basic Curve

```
\filldraw [gray]
(0,0) circle (2pt)
(1,1) circle (2pt)
(3,3) circle (2pt)
(3,0) circle (2pt);
\draw (0,0) .. controls (1,1) and (3,3) .. (3,0);
```

The above shows a basic curve where the control points are explicitly drawn as well. Obviously, this would be ommited (on your graph theory course home work for example).

2.2.1 Bezier Curves and the Bernstein Polynomial

This section gives some mathematical background on curved paths and is skippable.

Definition 2.2.1 (Bézier Curve)
A recursive definition for the Bézier curve of degree n expresses it as a point-to-point linear combination (interpolation) of a pair of corresponding points in two Bézier curves of degree $n-1$.

$$
\begin{aligned}
B &: \mathbb{R} \to \mathbb{R} \\
B_{P_0}(t) &= P_0 && \text{base case} \\
B(t) &= B_{P_0 P_1 \ldots P_n}(t) = (1-t) B_{P_0 P_1 \ldots P_{n-1}}(t) + t B_{P_1 P_2 \ldots P_n}(t)
\end{aligned}
$$

Definition 2.2.2 (Bernstein Basis Polynomials)
of degree n are given by

$$\left\{ b_{i,n}(t) = \binom{n}{i} t^i (1-t)^{n-i} : 0 \leq i \leq n \right\}$$

which form a basis of polynomials with degree at most n.

Proposition 2.2.1

$$B(t) = \sum_{i=0}^{n} \binom{n}{i} t^i (1-t)^{n-i} P_i$$

So we can express a Bézier curve as a linear combination of the Berstein Basis.

The points P_i are called *Control Points* for the Bézier Curve. The polygon formed by connecting the Bézier points with lines, starting with P_0 and finishing with P_n, gives the *Bézier Polygon (Control Polygon)*. The convex hull of the Bézier Polygon contains the Bézier Curve.

2.3 Circular Paths

Although it would certainly be possible to draw all our circular paths with control points, it would prove tedious to say the least.

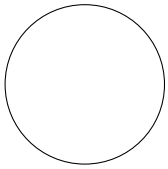

Figure 4: Basic Circle

```
\tikz \draw (0,0) circle (30pt);
```

We can also draw Ellipses.

Figure 5: Basic Ellipse

```
\tikz \draw (0,0) ellipse (20pt and 10pt);
```

Although it is possible to draw ellipses which are rotated in arbitrary directions, we will leave this for the section on transformations later on.