In this post I'm gonna show you how to calculate Legendre polynomials using three different techniques: using recurrence relations, series representations, and numerical integration.
The programs will calculate and plot the first few Legendre polynomials.

Using Recurrence Relation

We will be using the following recurrence relation:

$$(l+1)P_{l+1}(x) - (2l+1)xP_l(x) + lP_{l-1}(x) = 0$$

We would need two more relations, that is the relations for 0th and 1st order Legendre polynomials:

$$P_0(x) = 1$$
$$P_1(x) = x$$

We will create a program that calculates the values of the Legendre polynomial at various x values and for different l and store these values in a txt file. Then just plot it using Gnuplot.
We will create two functions called 'P0' and 'P1', that contain the definition of respectively.
Then we will create a function 'Pn' that will use the first two functions and recursion to find the value of Legendre polynomial for different x,l.
NOTE: I am using a slightly modified form of the recurrence relation. To get the form I am using, just replace l by l-1.
To get :

$$P_l(x) = ((2l-1)xP_{l-1}(x) - (l-1)P_{l-2}(x))/l$$

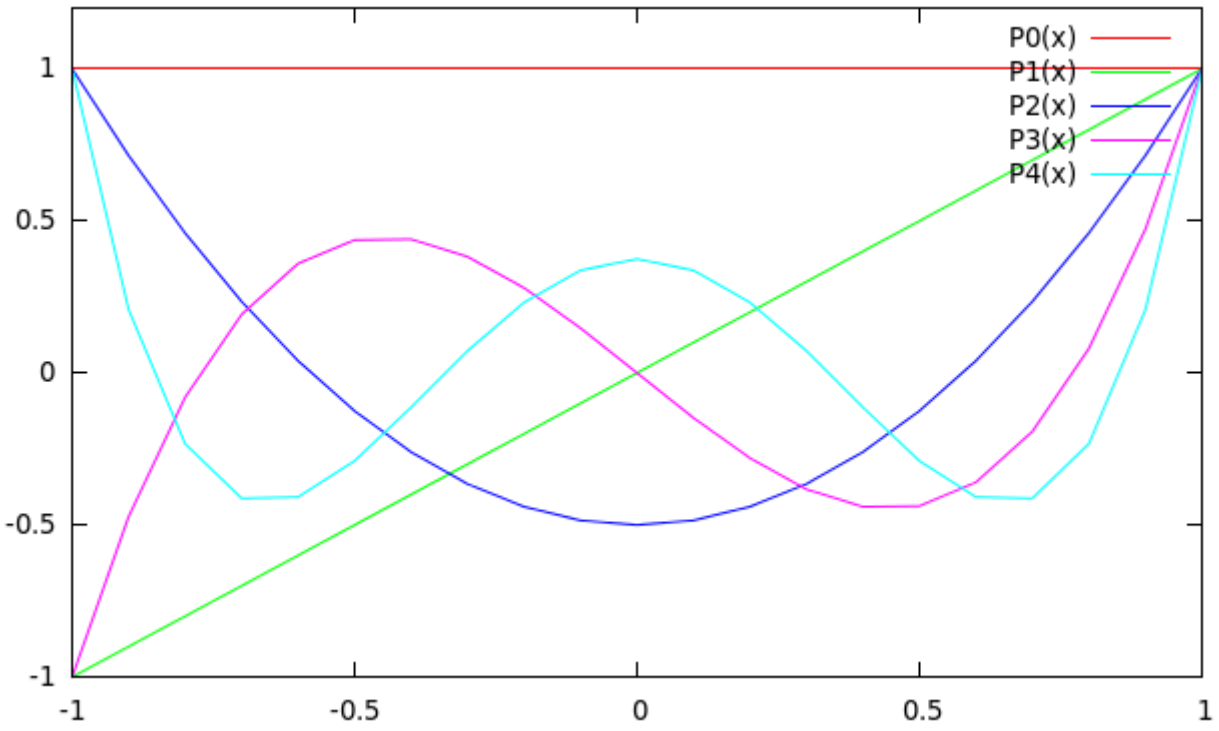
CODE:

```
#include<stdio.h>
#include<math.h>

double P0(double x){
        return 1;
}

double P1(double x){
        return x;
}
//The following is a general functoin that returns the value of the Legendre Polynomial
for any given x and n=0,1,2,3,...
double Pn(double x, int n){
        if(n==0){
                return P0(x);
        }else if(n==1){
                return P1(x);
        }else{
                return (double)((2*n-1)*x*Pn(x,n-1)-(n-1)*Pn(x,n-2))/n;
        }
}
main(){
        //We will create a data-file and store the values of first few Legendre
polynomials for -1<x<1
        FILE *fp=NULL;
        //create data-file
        fp=fopen("legendre1.txt","w");
        double x;
        //write the values of first 5 Legendre polynomials to data-file
        for(x=-1;x<=1;x=x+0.1){
fprintf(fp,"%lf\t%lf\t%lf\t%lf\t%lf\t%lf\n",x,Pn(x,0),Pn(x,1),Pn(x,2),Pn(x,3),Pn(x,4));
        }
}
```

OUTPUT:

The above program will create a data-file called `legendre1.txt` and store the values of the first 5 Legendre polynomials for $-1 \leq x \leq 1$. Now, you can just open the file and select the data and plot it using Excel, GnuPlot, Origin, etc.
For GnuPlot, the command is:

```
plot './legendre1.txt' u 1:2 w l t 'P0(x)','' u 1:3 w l t 'P1(x)', '' u 1:4 w l t 'P2(x)', '' u
1:5 w l t 'P3(x)', '' u 1:6 w l t 'P4(x)'
```



First 5 Legendre polynomials using recurrence relation

YouTube Tutorial:

Using Series Representation

Using Numerical Integration

References:

http://mathworld.wolfram.com/LegendrePolynomial.html

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I'm a physicist specializing in computational material science with a PhD in Physics from Friedrich-Schiller University Jena, Germany. I write efficient codes for simulating light-matter interactions at atomic scales. I like to develop Physics, DFT, and Machine Learning related apps and software from time to time. Can code in most of the popular languages. I like to share my knowledge in Physics and applications using this Blog and a YouTube channel.

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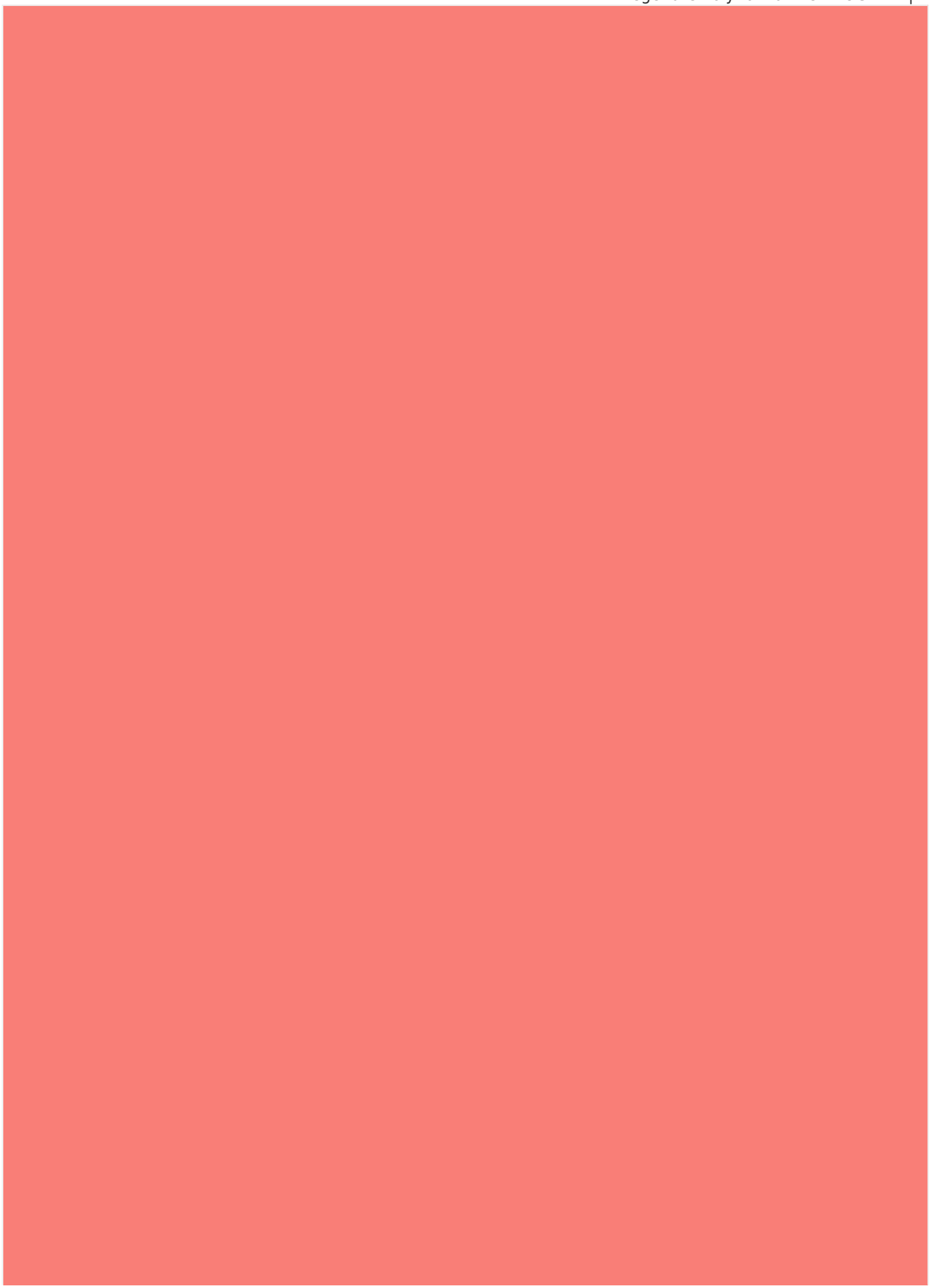

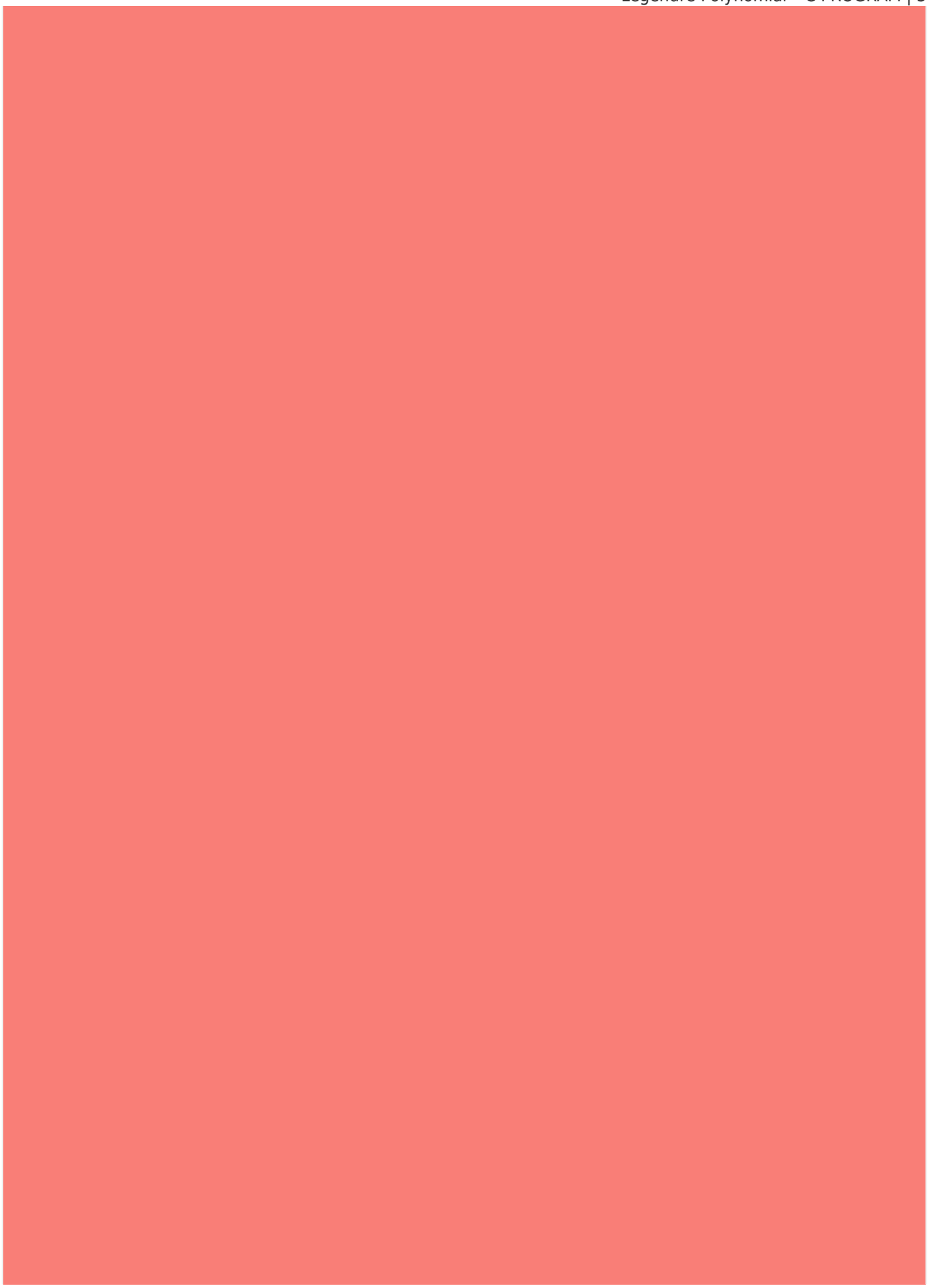

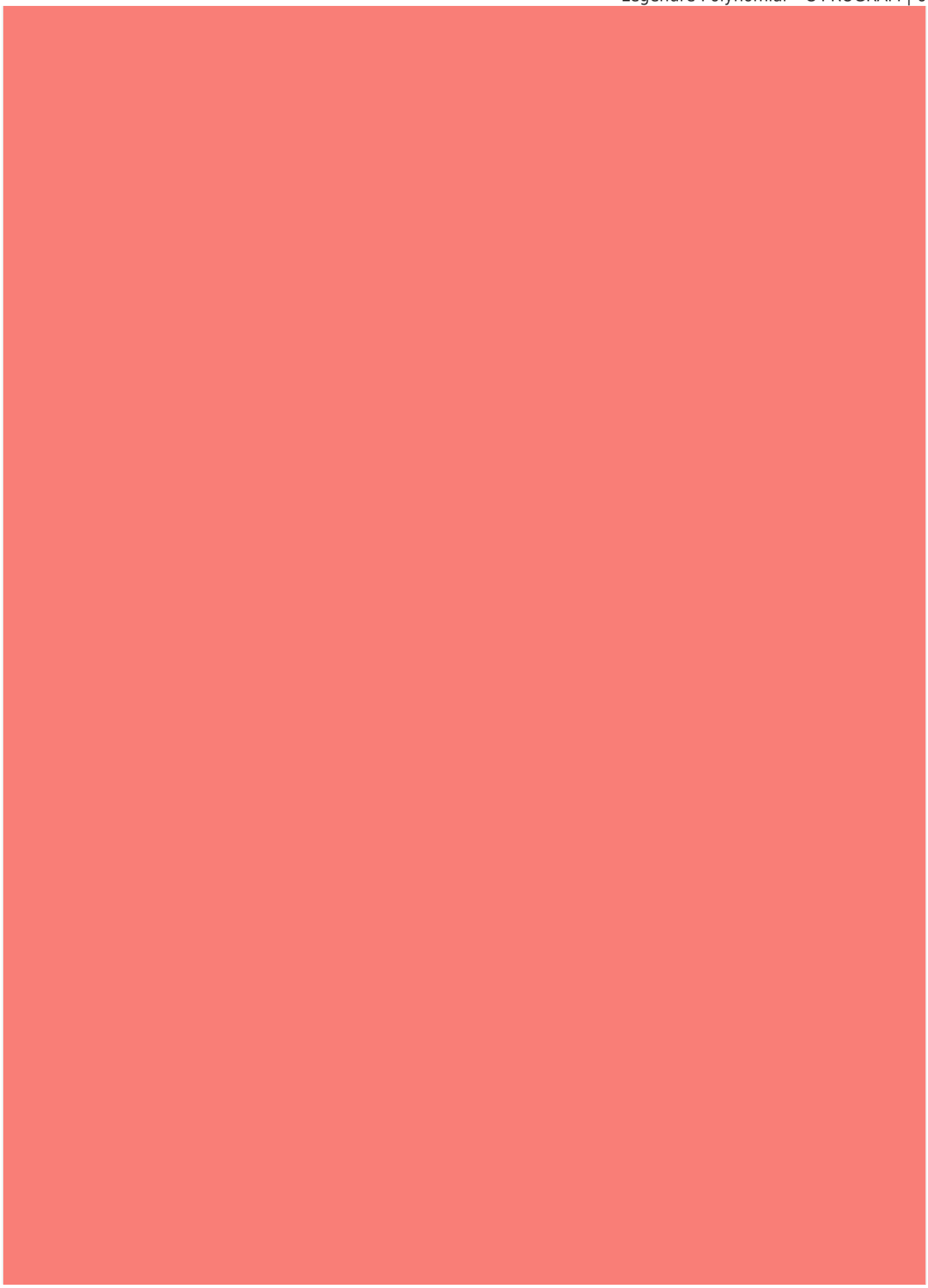

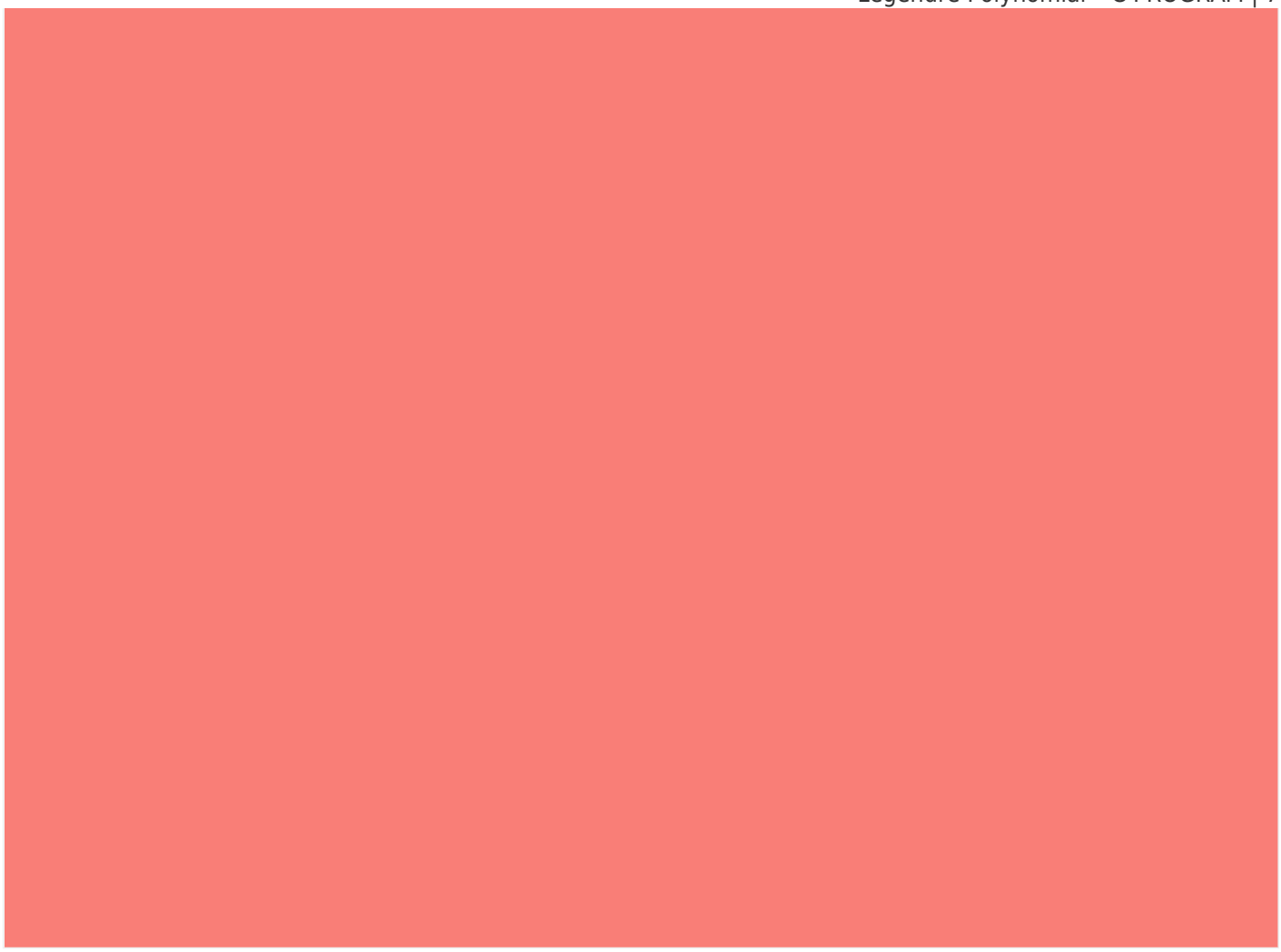

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