Цель: Сформировать практические навыки аппроксимации табличных функций с помощью сглаживающих сплайнов.

Расчеты:

Скриншот части вычисленных значений так как число наблюдений = 1953:

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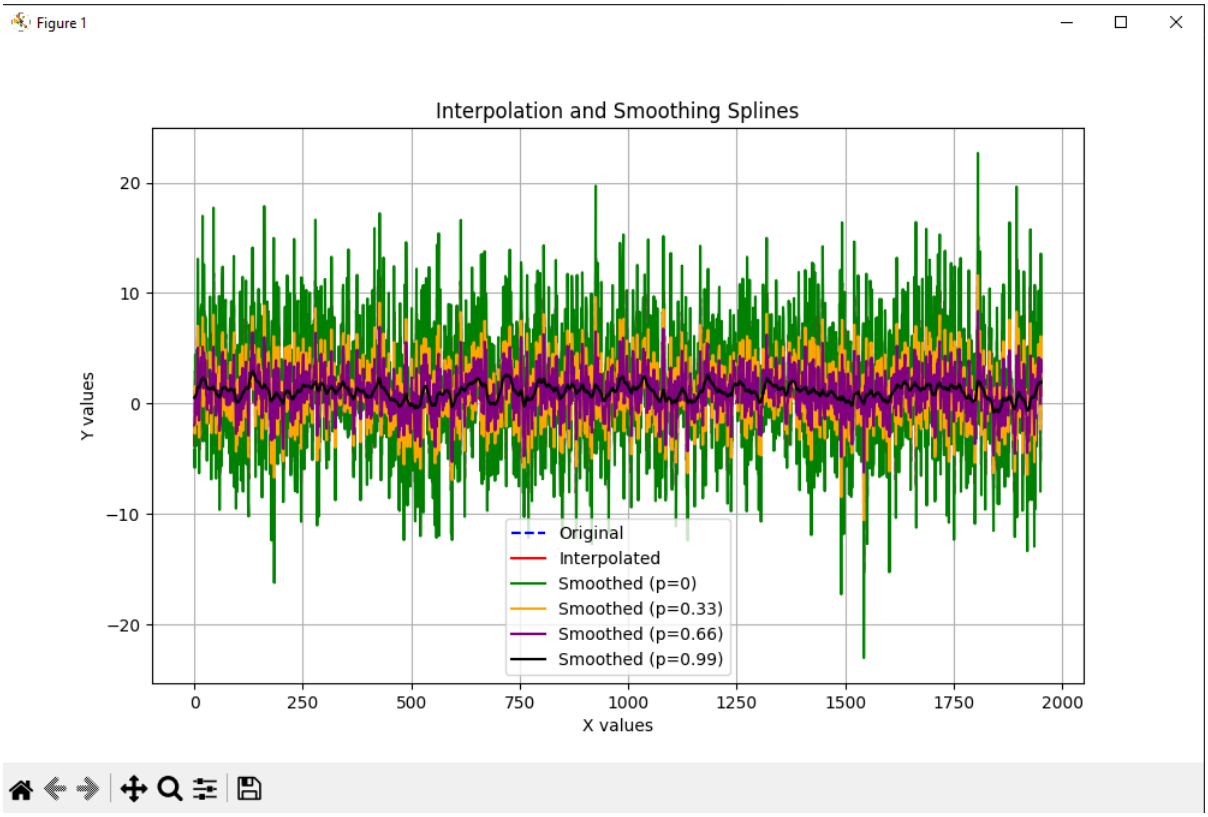
Original Y value: 1.71693 | Interpolated result: 1.71693 | Smoothed (p = 0): 2.57539 | Smoothed (p = 0.33): 1.80807 | Smoothed (p = 0.66): 1.97652 | Smoothed (p = 0.99): 0.772021
Original Y value: 3.639 | Interpolated result: 3.639 | Smoothed (p = 0): 5.4585 | Smoothed (p = 0.33): 3.85173 | Smoothed (p = 0.66): 3.61465 | Smoothed (p = 0.99): 0.932566
Original Y value: 8.0218 | Interpolated result: 8.0218 | Smoothed (p = 0): 12.0327 | Smoothed (p = 0.33): 6.7592 | Smoothed (p = 0.66): 5.2277 | Smoothed (p = 0.99): 1.03843
Original Y value: 4.74907 | Interpolated result: 4.74907 | Smoothed (p = 0): 7.1236 | Smoothed (p = 0.33): 4.53974 | Smoothed (p = 0.66): 3.96199 | Smoothed (p = 0.99): 1.00323
Original Y value: 0.894093 | Interpolated result: 0.894093 | Smoothed (p = 0): 1.34114 | Smoothed (p = 0.33): 1.47027 | Smoothed (p = 0.66): 1.88535 | Smoothed (p = 0.99): 0.892343
Original Y value: 1.04631 | Interpolated result: 1.04631 | Smoothed (p = 0): 1.56946 | Smoothed (p = 0.33): 0.74043 | Smoothed (p = 0.66): 0.830007 | Smoothed (p = 0.99): 0.781425
Original Y value: -1.78725 | Interpolated result: -1.78725 | Smoothed (p = 0): -2.68088 | Smoothed (p = 0.33): -1.23146 | Smoothed (p = 0.66): -0.448194 | Smoothed (p = 0.99): 0.665156
Original Y value: -1.29836 | Interpolated result: -1.29836 | Smoothed (p = 0): -1.94754 | Smoothed (p = 0.33): -0.946498 | Smoothed (p = 0.66): -0.346756 | Smoothed (p = 0.99): 0.59843
Original Y value: 0.457001 | Interpolated result: 0.457001 | Smoothed (p = 0): 0.685501 | Smoothed (p = 0.33): 0.767245 | Smoothed (p = 0.66): 0.735123 | Smoothed (p = 0.99): 0.570024
Original Y value: 5.25067 | Interpolated result: 5.25067 | Smoothed (p = 0): 7.876 | Smoothed (p = 0.33): 3.74077 | Smoothed (p = 0.66): 2.10355 | Smoothed (p = 0.99): 0.5439
Original Y value: 1.05211 | Interpolated result: 1.05211 | Smoothed (p = 0): 1.57817 | Smoothed (p = 0.33): 0.583185 | Smoothed (p = 0.66): 0.229498 | Smoothed (p = 0.99): 0.422691
Original Y value: -6.47087 | Interpolated result: -6.47087 | Smoothed (p = 0): -9.7063 | Smoothed (p = 0.33): -4.47852 | Smoothed (p = 0.66): -2.4921 | Smoothed (p = 0.99): 0.288766
Original Y value: -0.821886 | Interpolated result: -0.821886 | Smoothed (p = 0): -1.23283 | Smoothed (p = 0.33): -1.45009 | Smoothed (p = 0.66): -1.11435 | Smoothed (p = 0.99): 0.291399
Original Y value: -2.50263 | Interpolated result: -2.50263 | Smoothed (p = 0): -3.75394 | Smoothed (p = 0.33): -0.972566 | Smoothed (p = 0.66): -0.0379335 | Smoothed (p = 0.99): 0.316523
Original Y value: 7.96159 | Interpolated result: 7.96159 | Smoothed (p = 0): 11.9424 | Smoothed (p = 0.33): 5.71794 | Smoothed (p = 0.66): 3.57787 | Smoothed (p = 0.99): 0.398599
Original Y value: 3.45868 | Interpolated result: 3.45868 | Smoothed (p = 0): 5.18802 | Smoothed (p = 0.33): 3.29788 | Smoothed (p = 0.66): 2.67711 | Smoothed (p = 0.99): 0.327888
Original Y value: -0.809295 | Interpolated result: -0.809295 | Smoothed (p = 0): -1.21394 | Smoothed (p = 0.33): 0.224882 | Smoothed (p = 0.66): 0.971085 | Smoothed (p = 0.99): 0.193929
Original Y value: 1.70378 | Interpolated result: 1.70378 | Smoothed (p = 0): 2.55566 | Smoothed (p = 0.33): 1.35127 | Smoothed (p = 0.66): 1.0994 | Smoothed (p = 0.99): 0.0802362
Original Y value: 1.51619 | Interpolated result: 1.51619 | Smoothed (p = 0): 2.27429 | Smoothed (p = 0.33): 1.04626 | Smoothed (p = 0.66): 0.605014 | Smoothed (p = 0.99): -0.066255
Original Y value: -1.85475 | Interpolated result: -1.85475 | Smoothed (p = 0): -2.78213 | Smoothed (p = 0.33): -1.16697 | Smoothed (p = 0.66): -0.82816 | Smoothed (p = 0.99): -0.244715
Original Y value: 0.309462 | Interpolated result: 0.309462 | Smoothed (p = 0): 0.464192 | Smoothed (p = 0.33): -0.587395 | Smoothed (p = 0.66): -1.20363 | Smoothed (p = 0.99): -0.390649
Original Y value: -3.71348 | Interpolated result: -3.71348 | Smoothed (p = 0): -5.57022 | Smoothed (p = 0.33): -3.6496 | Smoothed (p = 0.66): -3.13806 | Smoothed (p = 0.99): -0.550726
Original Y value: -8.90572 | Interpolated result: -8.90572 | Smoothed (p = 0): -13.3586 | Smoothed (p = 0.33): -6.45243 | Smoothed (p = 0.66): -4.47962 | Smoothed (p = 0.99): -0.64691
Original Y value: 3.44964 | Interpolated result: 3.44964 | Smoothed (p = 0): 5.17445 | Smoothed (p = 0.33): 0.706594 | Smoothed (p = 0.66): -1.26095 | Smoothed (p = 0.99): -0.576249
Original Y value: -3.98653 | Interpolated result: -3.98653 | Smoothed (p = 0): -5.97979 | Smoothed (p = 0.33): -3.2728 | Smoothed (p = 0.66): -2.89561 | Smoothed (p = 0.99): -0.586919
Original Y value: -5.41884 | Interpolated result: -5.41884 | Smoothed (p = 0): -8.12826 | Smoothed (p = 0.33): -4.35401 | Smoothed (p = 0.66): -3.40629 | Smoothed (p = 0.99): -0.52891
Original Y value: 0.455446 | Interpolated result: 0.455446 | Smoothed (p = 0): 0.683169 | Smoothed (p = 0.33): -1.11137 | Smoothed (p = 0.66): -1.84344 | Smoothed (p = 0.99): -0.372114
Original Y value: -5.78513 | Interpolated result: -5.78513 | Smoothed (p = 0): -8.6777 | Smoothed (p = 0.33): -4.23094 | Smoothed (p = 0.66): -2.64914 | Smoothed (p = 0.99): -0.232037
Original Y value: -2.29489 | Interpolated result: -2.29489 | Smoothed (p = 0): -3.44233 | Smoothed (p = 0.33): -1.03953 | Smoothed (p = 0.66): -0.223812 | Smoothed (p = 0.99): 0.020224
Original Y value: 10.5034 | Interpolated result: 10.5034 | Smoothed (p = 0): 15.7551 | Smoothed (p = 0.33): 7.24938 | Smoothed (p = 0.66): 4.33535 | Smoothed (p = 0.99): 0.319255
Original Y value: 0.822527 | Interpolated result: 0.822527 | Smoothed (p = 0): 1.23379 | Smoothed (p = 0.33): 2.325 | Smoothed (p = 0.66): 2.53955 | Smoothed (p = 0.99): 0.412545
Original Y value: 5.34772 | Interpolated result: 5.34772 | Smoothed (p = 0): 8.02158 | Smoothed (p = 0.33): 3.50156 | Smoothed (p = 0.66): 2.51282 | Smoothed (p = 0.99): 0.497553
Original Y value: -5.81982 | Interpolated result: -5.81982 | Smoothed (p = 0): -8.72973 | Smoothed (p = 0.33): -2.81838 | Smoothed (p = 0.66): -0.434731 | Smoothed (p = 0.99): 0.484578
Original Y value: 4.24072 | Interpolated result: 4.24072 | Smoothed (p = 0): 6.36108 | Smoothed (p = 0.33): 3.04935 | Smoothed (p = 0.66): 2.166 | Smoothed (p = 0.99): 0.598965
Original Y value: 5.53551 | Interpolated result: 5.53551 | Smoothed (p = 0): 8.30327 | Smoothed (p = 0.33): 4.0794 | Smoothed (p = 0.66): 2.62913 | Smoothed (p = 0.99): 0.639781
Original Y value: -2.24513 | Interpolated result: -2.24513 | Smoothed (p = 0): -3.36769 | Smoothed (p = 0.33): -0.803231 | Smoothed (p = 0.66): 0.0978169 | Smoothed (p = 0.99): 0.581693
Original Y value: 0.557461 | Interpolated result: 0.557461 | Smoothed (p = 0): 0.836191 | Smoothed (p = 0.33): 0.169118 | Smoothed (p = 0.66): -0.0195536 | Smoothed (p = 0.99): 0.580712
Original Y value: 0.613785 | Interpolated result: 0.613785 | Smoothed (p = 0): 0.920678 | Smoothed (p = 0.33): -0.43544 | Smoothed (p = 0.66): -0.731424 | Smoothed (p = 0.99): 0.580202
Original Y value: -8.6334 | Interpolated result: -8.6334 | Smoothed (p = 0): -12.9501 | Smoothed (p = 0.33): -5.30049 | Smoothed (p = 0.66): -2.82927 | Smoothed (p = 0.99): 0.579012
Original Y value: 7.15617 | Interpolated result: 7.15617 | Smoothed (p = 0): 10.7343 | Smoothed (p = 0.33): 3.3681 | Smoothed (p = 0.66): 1.0529 | Smoothed (p = 0.99): 0.763933
Original Y value: -6.37138 | Interpolated result: -6.37138 | Smoothed (p = 0): -9.55707 | Smoothed (p = 0.33): -3.34517 | Smoothed (p = 0.66): -1.35314 | Smoothed (p = 0.99): 0.819717
Original Y value: 3.29729 | Interpolated result: 3.29729 | Smoothed (p = 0): 4.94593 | Smoothed (p = 0.33): 2.22978 | Smoothed (p = 0.66): 1.41111 | Smoothed (p = 0.99): 1.02078
Original Y value: 4.85474 | Interpolated result: 4.85474 | Smoothed (p = 0): 7.28211 | Smoothed (p = 0.33): 3.47001 | Smoothed (p = 0.66): 2.23203 | Smoothed (p = 0.99): 1.17584
Original Y value: -2.59431 | Interpolated result: -2.59431 | Smoothed (p = 0): -3.89146 | Smoothed (p = 0.33): -0.912644 | Smoothed (p = 0.66): 0.350754 | Smoothed (p = 0.99): 1.25659
Original Y value: 2.03724 | Interpolated result: 2.03724 | Smoothed (p = 0): 3.05586 | Smoothed (p = 0.33): 1.53327 | Smoothed (p = 0.66): 1.50378 | Smoothed (p = 0.99): 1.41513
Original Y value: 1.57472 | Interpolated result: 1.57472 | Smoothed (p = 0): 2.36208 | Smoothed (p = 0.33): 1.93278 | Smoothed (p = 0.66): 2.10719 | Smoothed (p = 0.99): 1.56111
Original Y value: 4.44541 | Interpolated result: 4.44541 | Smoothed (p = 0): 6.66812 | Smoothed (p = 0.33): 3.78623 | Smoothed (p = 0.66): 3.25921 | Smoothed (p = 0.99): 1.70681
Original Y value: 2.16321 | Interpolated result: 2.16321 | Smoothed (p = 0): 3.24482 | Smoothed (p = 0.33): 2.963 | Smoothed (p = 0.66): 3.18908 | Smoothed (p = 0.99): 1.79718
Original Y value: 6.80911 | Interpolated result: 6.80911 | Smoothed (p = 0): 10.2137 | Smoothed (p = 0.33): 5.38741 | Smoothed (p = 0.66): 4.1759 | Smoothed (p = 0.99): 1.88017
Original Y value: 1.22236 | Interpolated result: 1.22236 | Smoothed (p = 0): 1.83355 | Smoothed (p = 0.33): 2.03883 | Smoothed (p = 0.66): 2.44971 | Smoothed (p = 0.99): 1.86357
Original Y value: 2.16462 | Interpolated result: 2.16462 | Smoothed (p = 0): 3.24694 | Smoothed (p = 0.33): 2.00558 | Smoothed (p = 0.66): 1.98807 | Smoothed (p = 0.99): 1.85993
Original Y value: 2.06193 | Interpolated result: 2.06193 | Smoothed (p = 0): 3.0929 | Smoothed (p = 0.33): 1.3265 | Smoothed (p = 0.66): 1.34452 | Smoothed (p = 0.99): 1.85013
Original Y value: -5.31519 | Interpolated result: -5.31519 | Smoothed (p = 0): -7.97279 | Smoothed (p = 0.33): -2.3389 | Smoothed (p = 0.66): -0.0381697 | Smoothed (p = 0.99): 1.83606
Original Y value: 9.04029 | Interpolated result: 9.04029 | Smoothed (p = 0): 13.5604 | Smoothed (p = 0.33): 6.08129 | Smoothed (p = 0.66): 4.01607 | Smoothed (p = 0.99): 1.96646
Original Y value: 0.715397 | Interpolated result: 0.715397 | Smoothed (p = 0): 1.43079 | Smoothed (p = 0.33): 2.48614 | Smoothed (p = 0.66): 2.89384 | Smoothed (p = 0.99): 1.95394
```

Данные предаствленные в виде графика:



Выборка размером 10:

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Original Y value: 4.29027 | Interpolated result: 4.29027 | Smoothed (p = 0): 8.58053 | Smoothed (p = 0.33): 2.11201 | Smoothed (p = 0.66): 0.607518 | Smoothed (p = 0.99): 0.115814
Original Y value: -3.6099 | Interpolated result: -3.6099 | Smoothed (p = 0): -5.41486 | Smoothed (p = 0.33): -2.31052 | Smoothed (p = 0.66): -1.28966 | Smoothed (p = 0.99): 0.0736481
Original Y value: -1.90136 | Interpolated result: -1.90136 | Smoothed (p = 0): -2.85204 | Smoothed (p = 0.33): -1.45678 | Smoothed (p = 0.66): -0.796273 | Smoothed (p = 0.99): 0.105897
Original Y value: 1.17314 | Interpolated result: 1.17314 | Smoothed (p = 0): 1.7597 | Smoothed (p = 0.33): 1.20224 | Smoothed (p = 0.66): 0.835687 | Smoothed (p = 0.99): 0.178697
Original Y value: 6.08539 | Interpolated result: 6.08539 | Smoothed (p = 0): 9.12809 | Smoothed (p = 0.33): 3.97942 | Smoothed (p = 0.66): 2.11997 | Smoothed (p = 0.99): 0.231407
Original Y value: -3.11805 | Interpolated result: -3.11805 | Smoothed (p = 0): -4.67707 | Smoothed (p = 0.33): -1.7949 | Smoothed (p = 0.66): -0.68132 | Smoothed (p = 0.99): 0.165855
Original Y value: -3.44588 | Interpolated result: -3.44588 | Smoothed (p = 0): -5.16882 | Smoothed (p = 0.33): -2.19644 | Smoothed (p = 0.66): -0.972047 | Smoothed (p = 0.99): 0.166644
Original Y value: 4.02202 | Interpolated result: 4.02202 | Smoothed (p = 0): 6.03303 | Smoothed (p = 0.33): 2.47551 | Smoothed (p = 0.66): 1.28603 | Smoothed (p = 0.99): 0.240413
Original Y value: 0.809569 | Interpolated result: 0.809569 | Smoothed (p = 0): 1.21435 | Smoothed (p = 0.33): 0.867666 | Smoothed (p = 0.66): 0.725194 | Smoothed (p = 0.99): 0.237787
Original Y value: -1.17999 | Interpolated result: -1.17999 | Smoothed (p = 0): -2.35998 | Smoothed (p = 0.33): -0.504264 | Smoothed (p = 0.66): 0.0774314 | Smoothed (p = 0.99): 0.223609
```

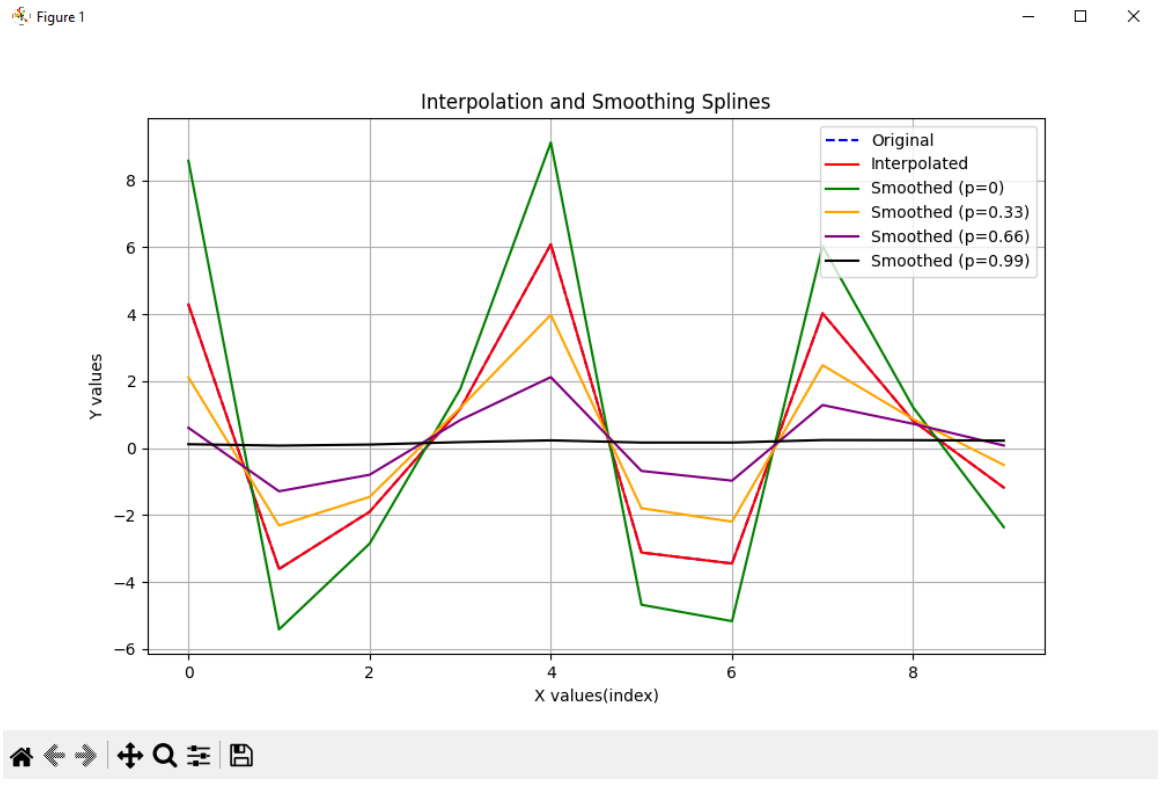

Вывод:

Интерполяция (красная кривая) не сглаживает данные и точно проходит через исходные точки.

Сглаживающие сплайны с параметром p p дают более гладкие кривые, уменьшая влияние небольших изменений значений в зависимости от степени сглаживания.

С увеличением p p сглаживание становится более заметным, что хорошо видно на примере черной линии (p = 0.99).

Для данных с большим количеством точек сглаживание помогает устранить шум и лучше выявить основные тренды. При p = 0 сглаживающий сплайн начинает работать как интерполяционный А при p близком к 1 значения сглаживающего сплайна приближаются к среднему.