Statistical Machine Learning

Part I: Statistical Learning Theory

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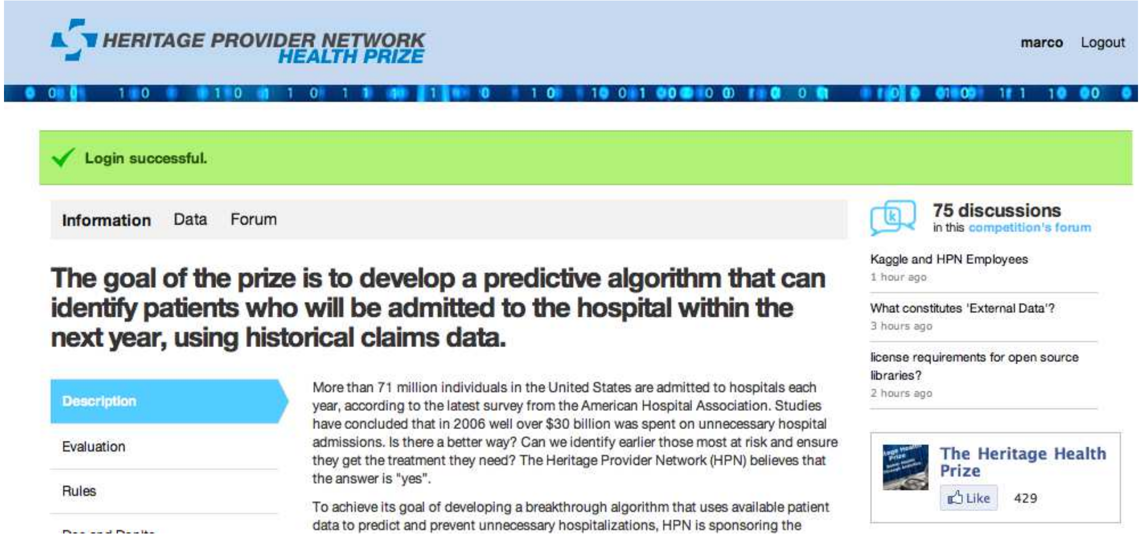
Course Introduction

- The Promises of Big Data
- What kind of tools will we use?
- Do we have to program?
- For starters... a first assignment
- Why is this useful for me?

The Promises of Big Data

Personal Health

- Data can help us predict when people will have to go to the hospital



HERITAGE PROVIDER NETWORK
HEALTH PRIZE

marco Logout

✓ Login successful.

Information Data Forum

The goal of the prize is to develop a predictive algorithm that can identify patients who will be admitted to the hospital within the next year, using historical claims data.

Description

Evaluation

Rules

More than 71 million individuals in the United States are admitted to hospitals each year, according to the latest survey from the American Hospital Association. Studies have concluded that in 2006 well over $30 billion was spent on unnecessary hospital admissions. Is there a better way? Can we identify earlier those most at risk and ensure they get the treatment they need? The Heritage Provider Network (HPN) believes that the answer is "yes".

To achieve its goal of developing a breakthrough algorithm that uses available patient data to predict and prevent unnecessary hospitalizations, HPN is sponsoring the

75 discussions
in this competition's forum

Kaggle and HPN Employees
1 hour ago

What constitutes 'External Data'?
3 hours ago

license requirements for open source libraries?
2 hours ago

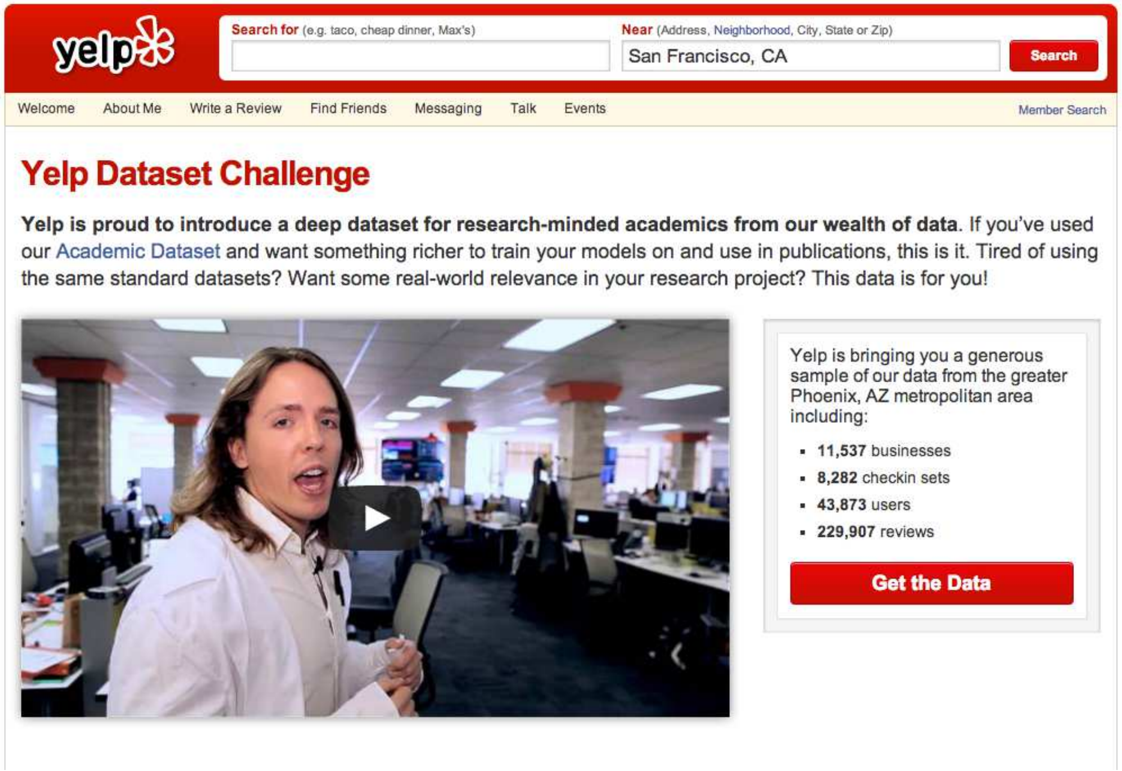
The Heritage Health Prize
Like 429

Started: 5:03 pm, Monday 4 April 2011 UTC
Ends: 6:59 am, Wednesday 3 April 2013 UTC (729 total days)

Heritage Health Prize

Small Businesses

- Data can help us predict the dynamics of restaurants' popularity



Yelp Dataset Challenge

Yelp is proud to introduce a deep dataset for research-minded academics from our wealth of data. If you've used our Academic Dataset and want something richer to train your models on and use in publications, this is it. Tired of using the same standard datasets? Want some real-world relevance in your research project? This data is for you!

Yelp is bringing you a generous sample of our data from the greater Phoenix, AZ metropolitan area including:

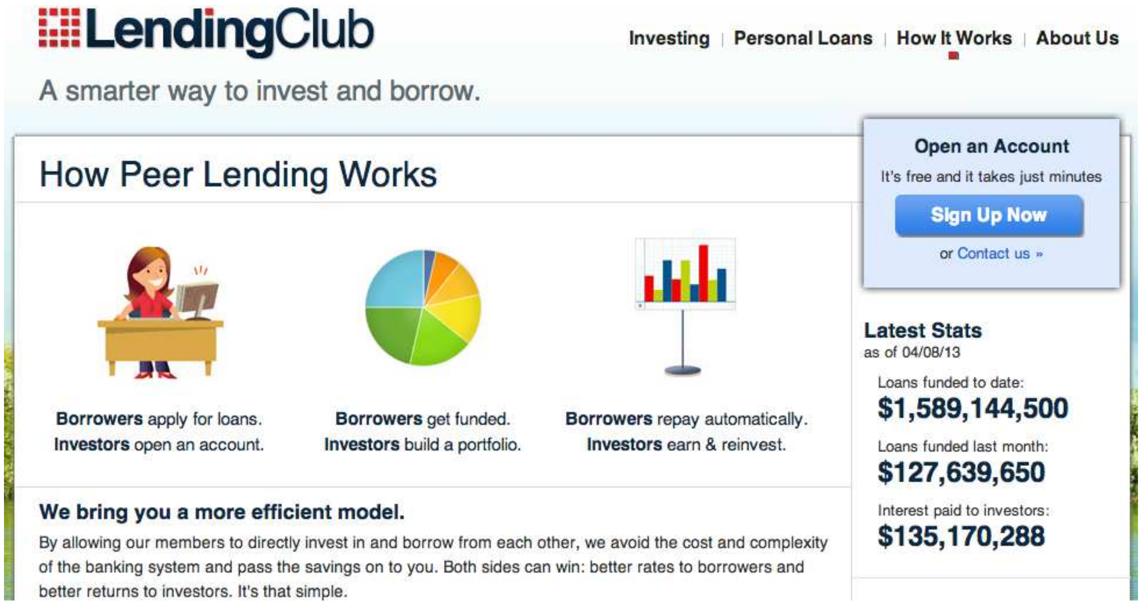
- **11,537** businesses
- **8,282** checkin sets
- **43,873** users
- **229,907** reviews

Yelp.com dataset challenge

Lending Money

- Data can help us predict who we can lend money to

LendingClub zopa AQUSH アクシュ



LendingClub

A smarter way to invest and borrow.

How Peer Lending Works

Borrowers apply for loans.
Investors open an account.

Borrowers get funded.
Investors build a portfolio.

Borrowers repay automatically.
Investors earn & reinvest.

We bring you a more efficient model.

By allowing our members to directly invest in and borrow from each other, we avoid the cost and complexity of the banking system and pass the savings on to you. Both sides can win: better rates to borrowers and better returns to investors. It's that simple.

Open an Account

It's free and it takes just minutes

Latest Stats
as of 04/08/13

Loans funded to date:
$1,589,144,500

Loans funded last month:
$127,639,650

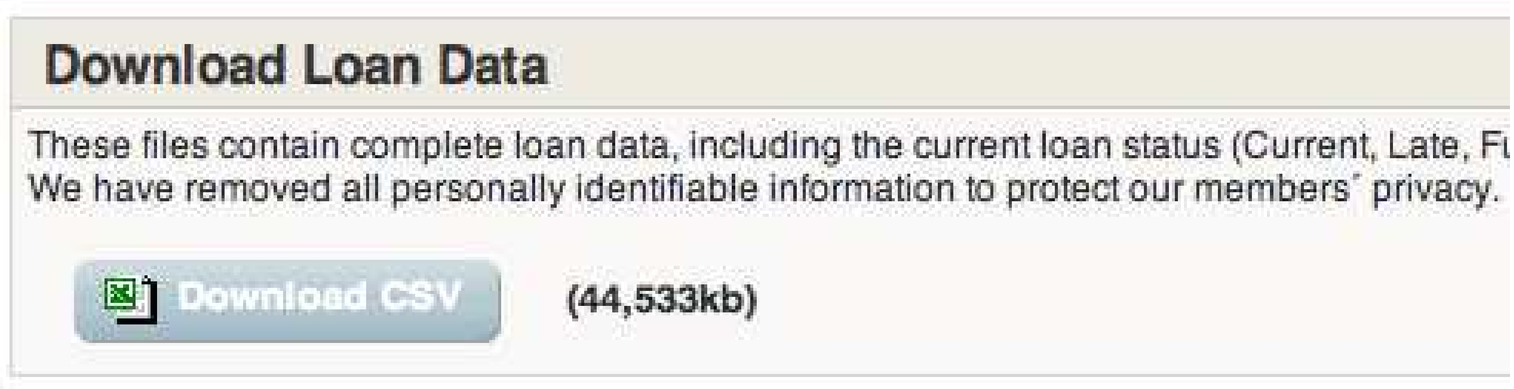
Interest paid to investors:
$135,170,288

www.lendingclub.com

Lending Money

- Data can help us predict who we can lend money to

LendingClub zopa™ AQUSH アクシュ



Download Loan Data

These files contain complete loan data, including the current loan status (Current, Late, Fu
We have removed all personally identifiable information to protect our members' privacy.

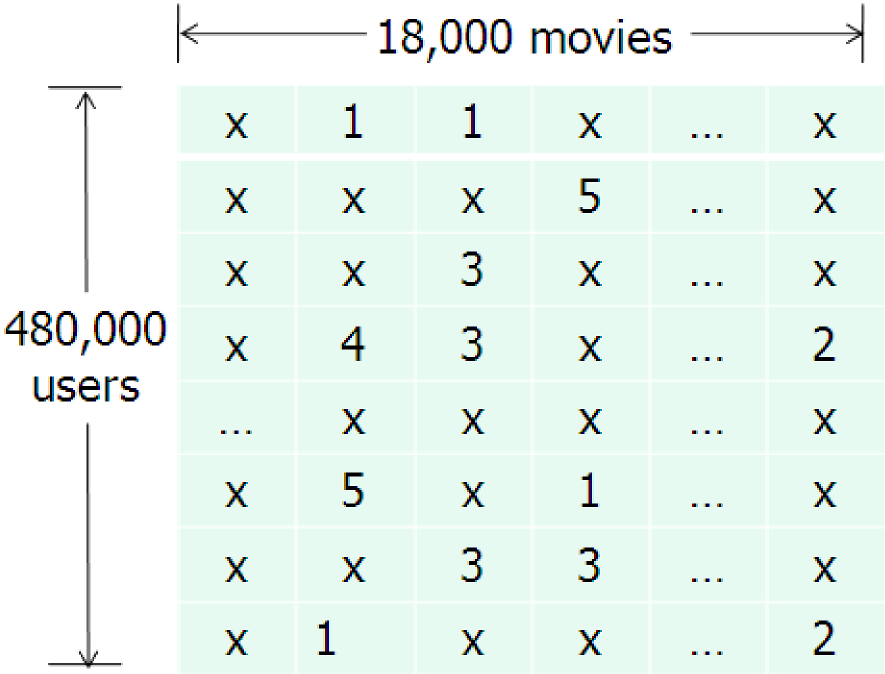
(44,533kb)

www.lendingclub.com

Movies

- Data can help us predict whether people will like a given movie

Netflix Prize, Research@ATT



18,000 movies

480,000 users

x	1	1	x	...	x
x	x	x	5	...	x
x	x	3	x	...	x
x	4	3	x	...	2
...	x	x	x	...	x
x	5	x	1	...	x
x	x	3	3	...	x
x	1	x	x	...	2

Hao Zhang

All these problems have in common that...

Data is Available

all you have to do, is download it... and **analyze it**!

What we will do in 7 lectures

The graduate school has many courses on how to handle data.
Check the course offerings.

In these 7 lectures, **we will focus on 3 things**:

- Present elementary tools: **regression** and **classification**
- Study the **mathematical foundations** of **statistical learning theory**:
  - Choose the right models, address computational issues,
  - Address the problem of **overfitting**.
- Introduce advanced topics: **kernel methods, sparsity**.

What kind of mathematical tools?

We will adopt a **mathematical formalism** to propose and study algorithms.

Probability & Statistics, Linear Algebra, Optimization

Mathematical Tools

- **Probability & Statistics** *(to handle uncertainty & randomness)*
  - Probability Spaces, Random variables
  - Expectation, variance, inequalities
  - Central limit theorem, convergence in probability

- **Linear Algebra** *(to handle high-dimensional problems)*
  - Matrix inverse, eigenvalues/vectors
  - Positive-definiteness.

- **Optimization** *(to give the best possible answer)*
  - convex programs,
  - lagrangean, Lagrange multipliers etc.

Programming

This is not a course about programming, but we **will** implement algorithms

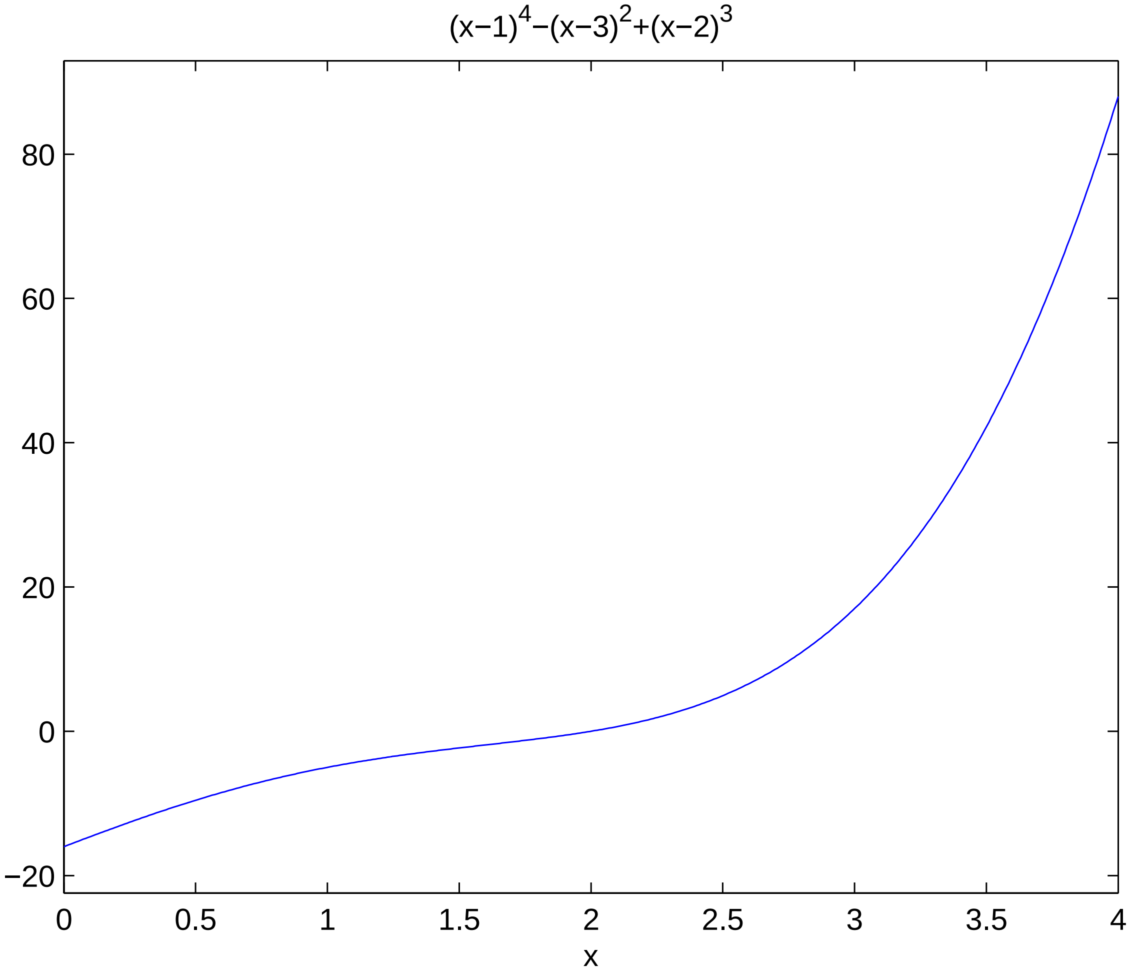
I encourage you to use **MATLAB**
but you can use any other program (R, Python, etc...)

I **do not recommend** using C/C++ or other compiled languages.

For Starters...

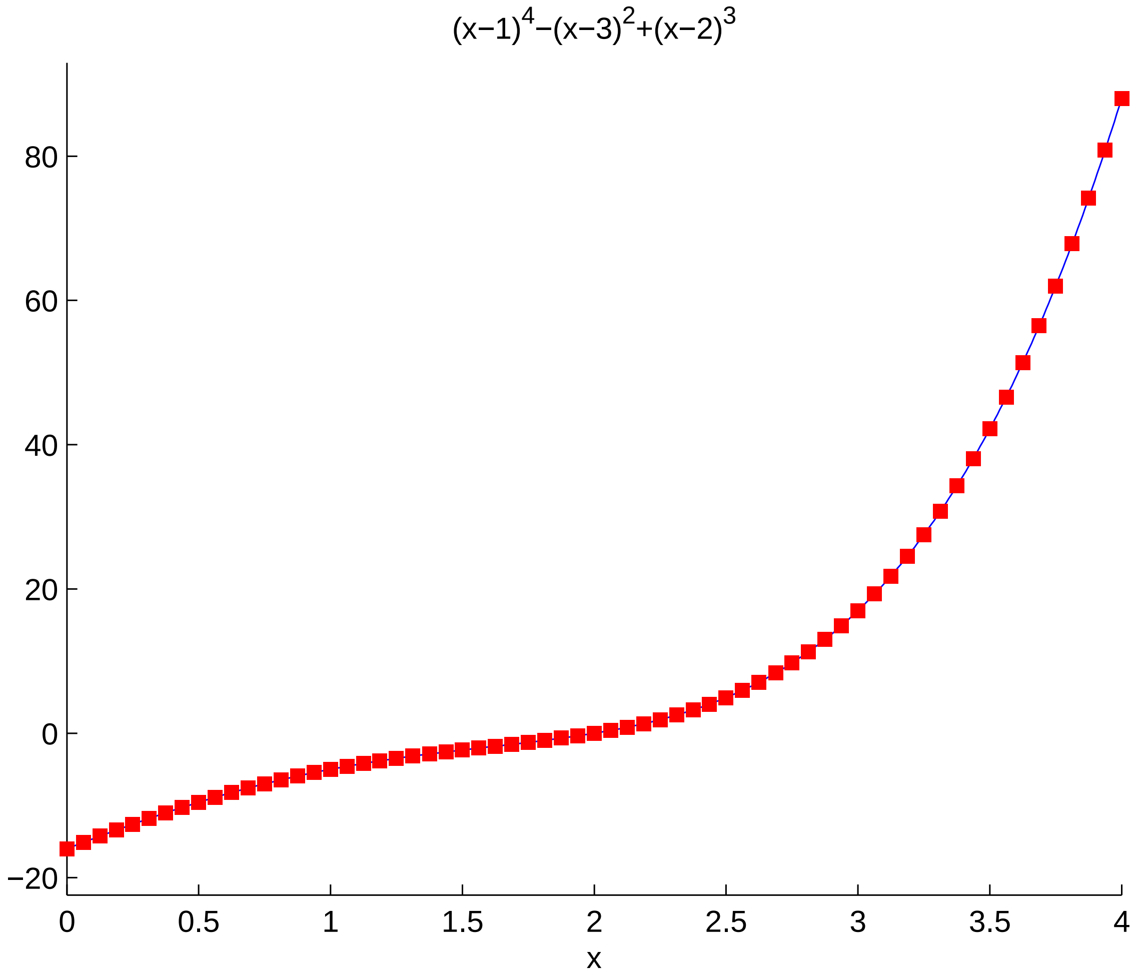
Some simple ideas and a 1st assignment.

A function



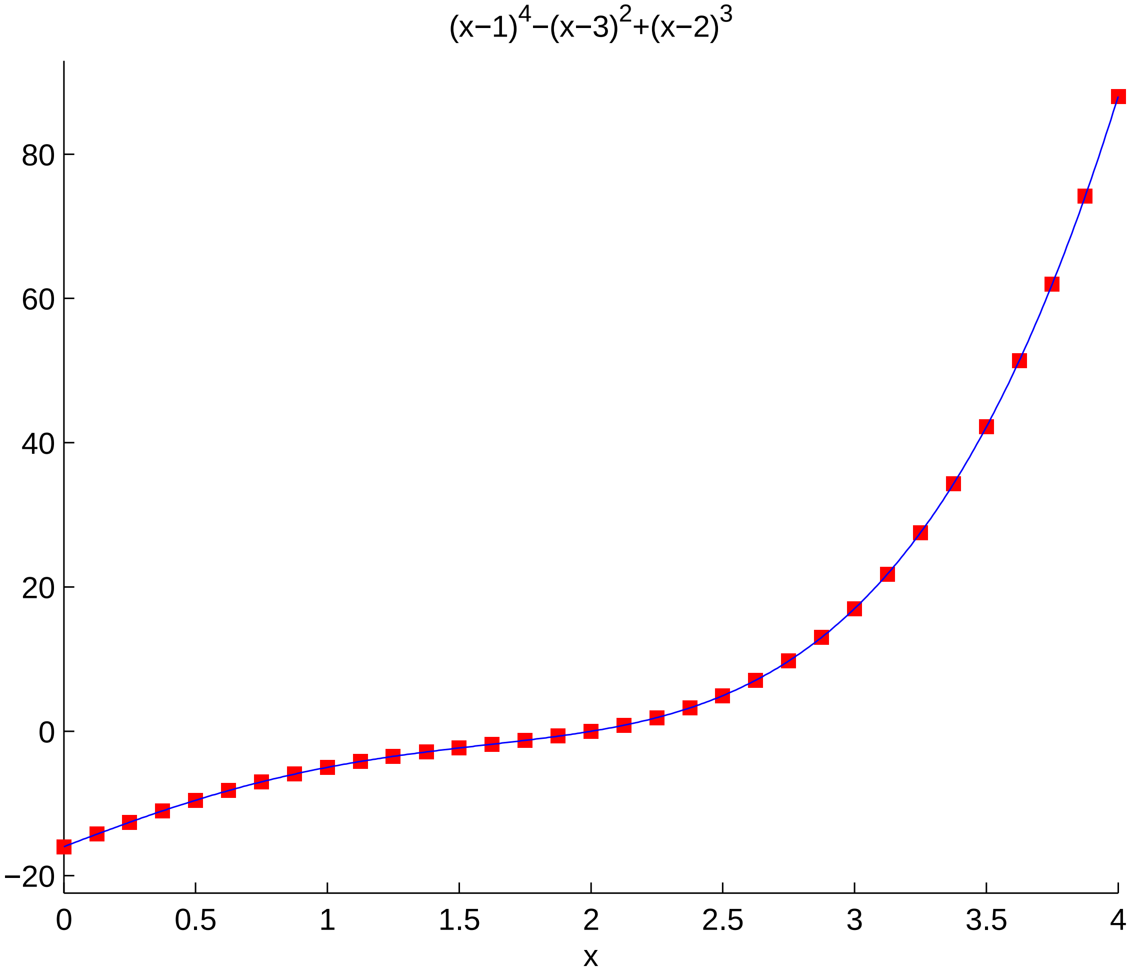
a polynomial plotted between 0 and 4...

A function



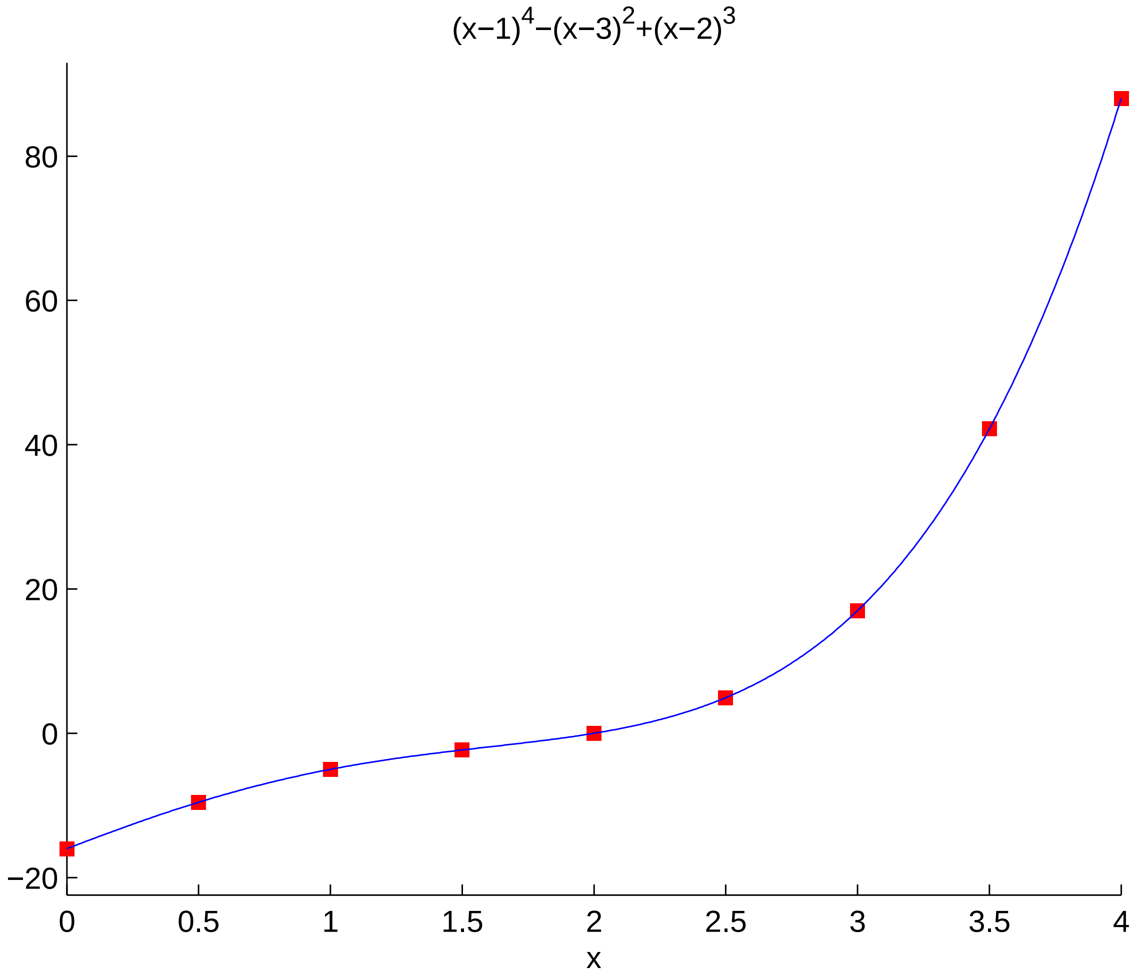
... can be seen as a very detailed scatter plot.

A function



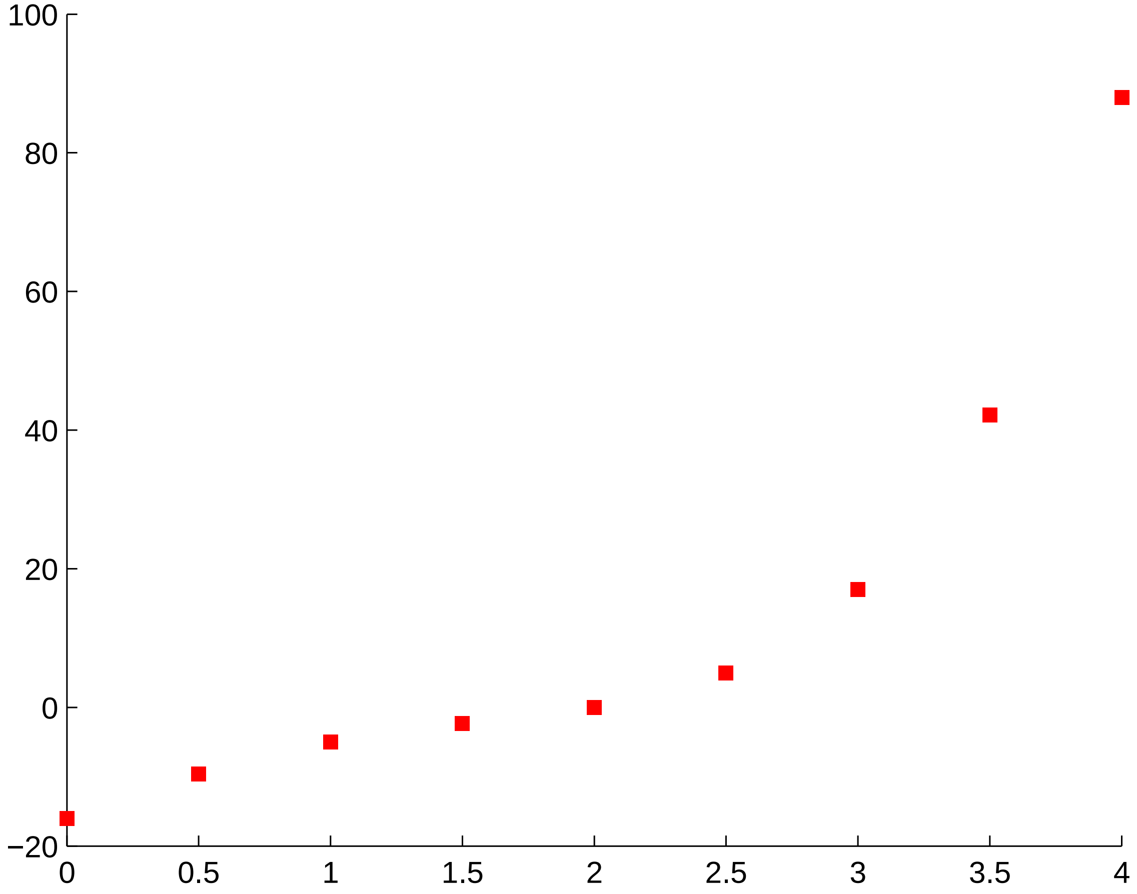
Yet, when less points are available...

A function



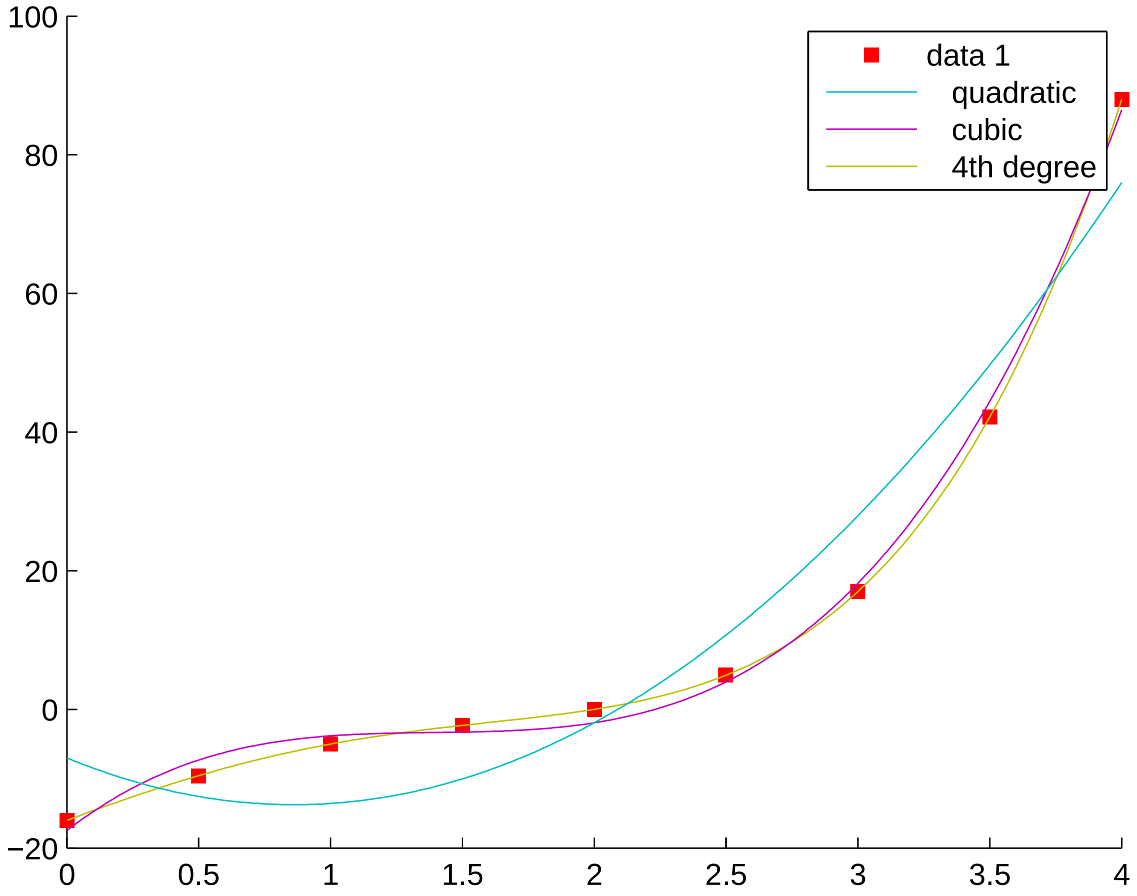
can we still guess the whole blue line?

A partially observed function



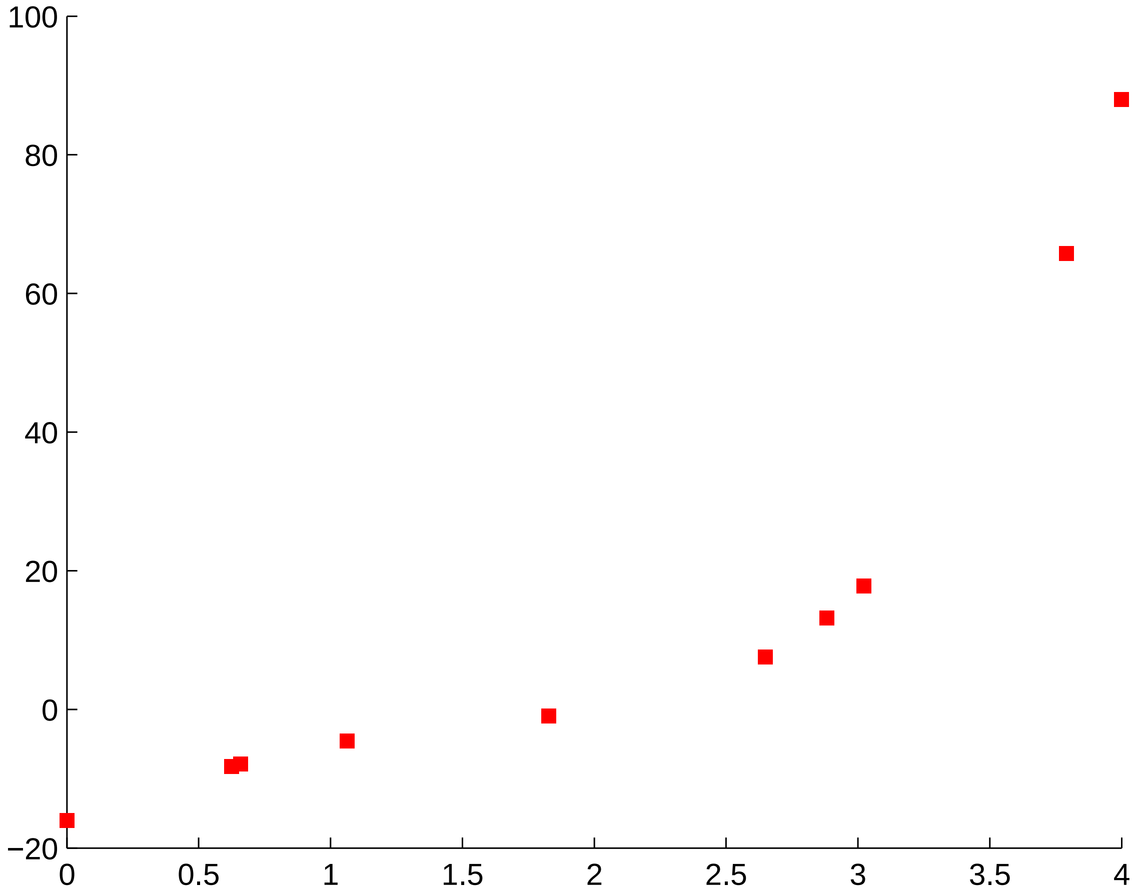
Assume we only have the red points.

We can guess by using interpolating polynomials



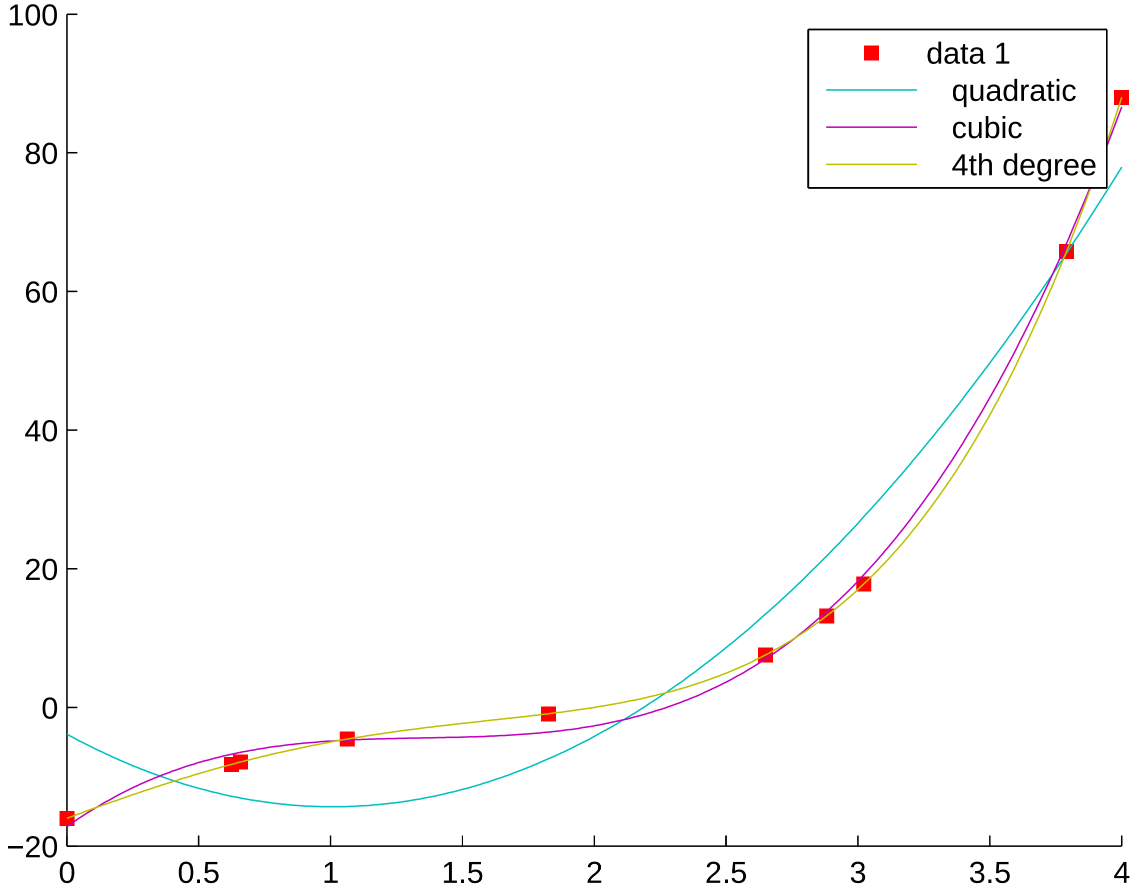
Curve fitting tools can help us get back the original function.
We can actually reconstruct it **perfectly**.

Polynomial Interpolation

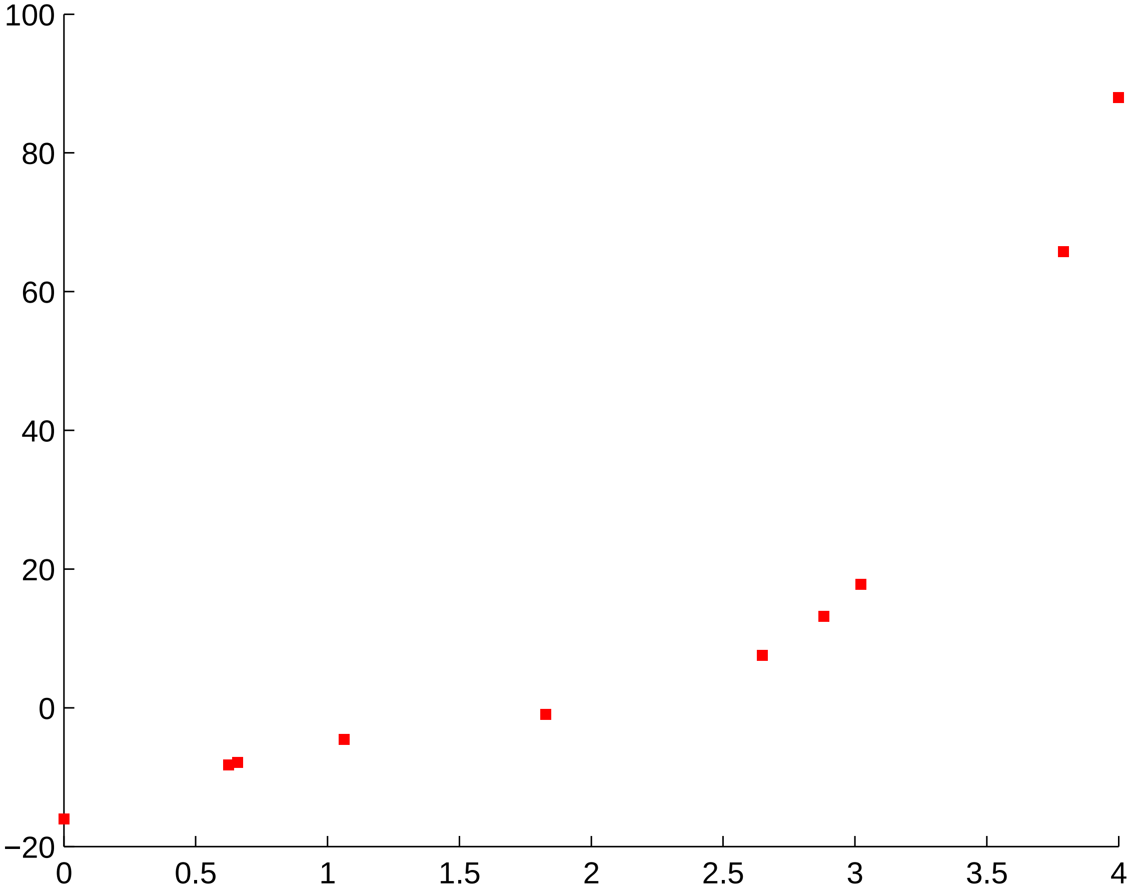


even if points are not evenly spaced...

Polynomial Interpolation

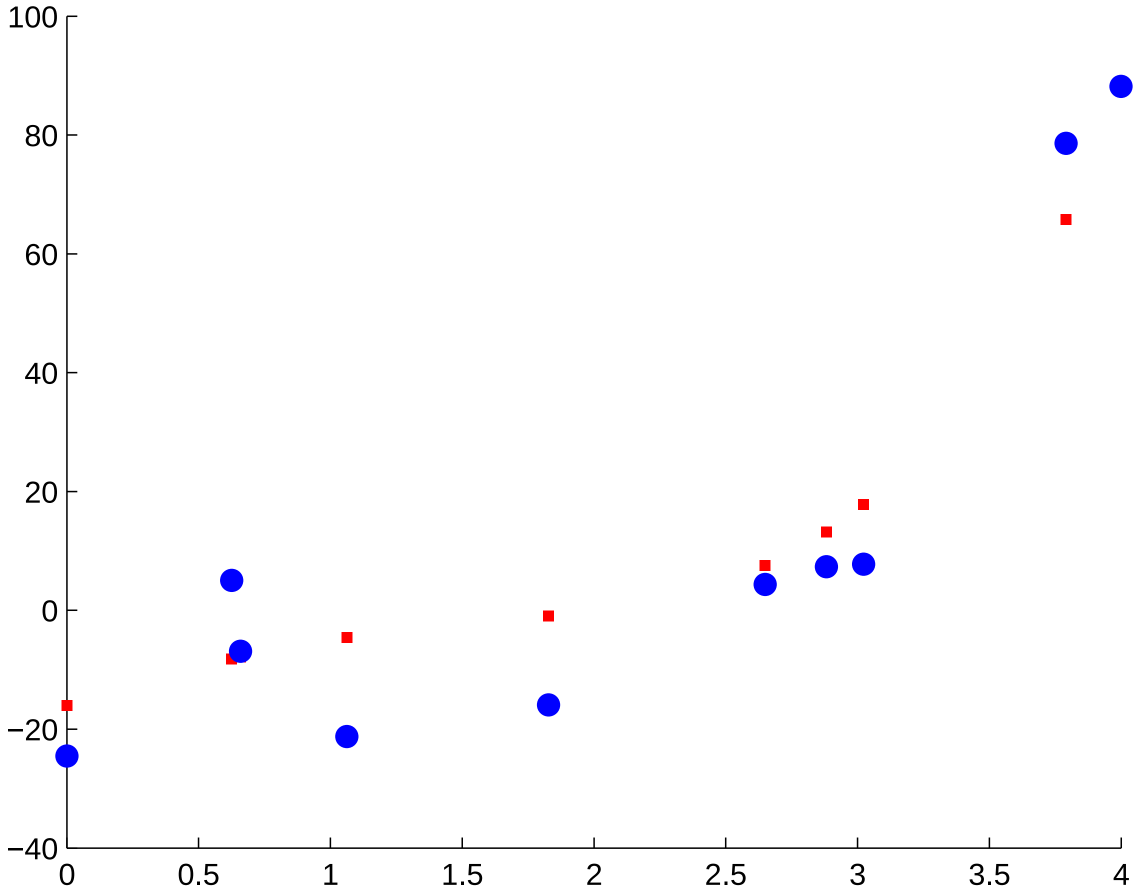


Uncertainty in measurements



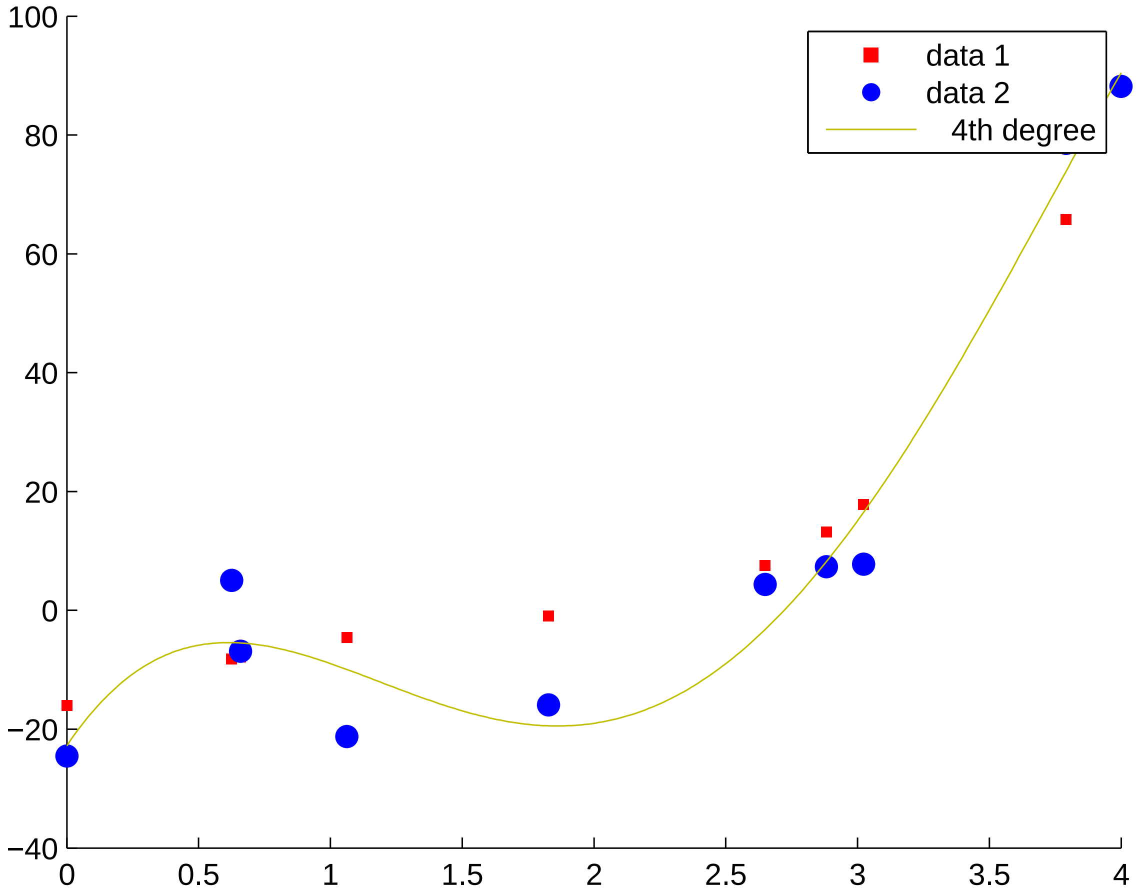
sometimes, we do not have access to the correct information...

Uncertainty in measurements



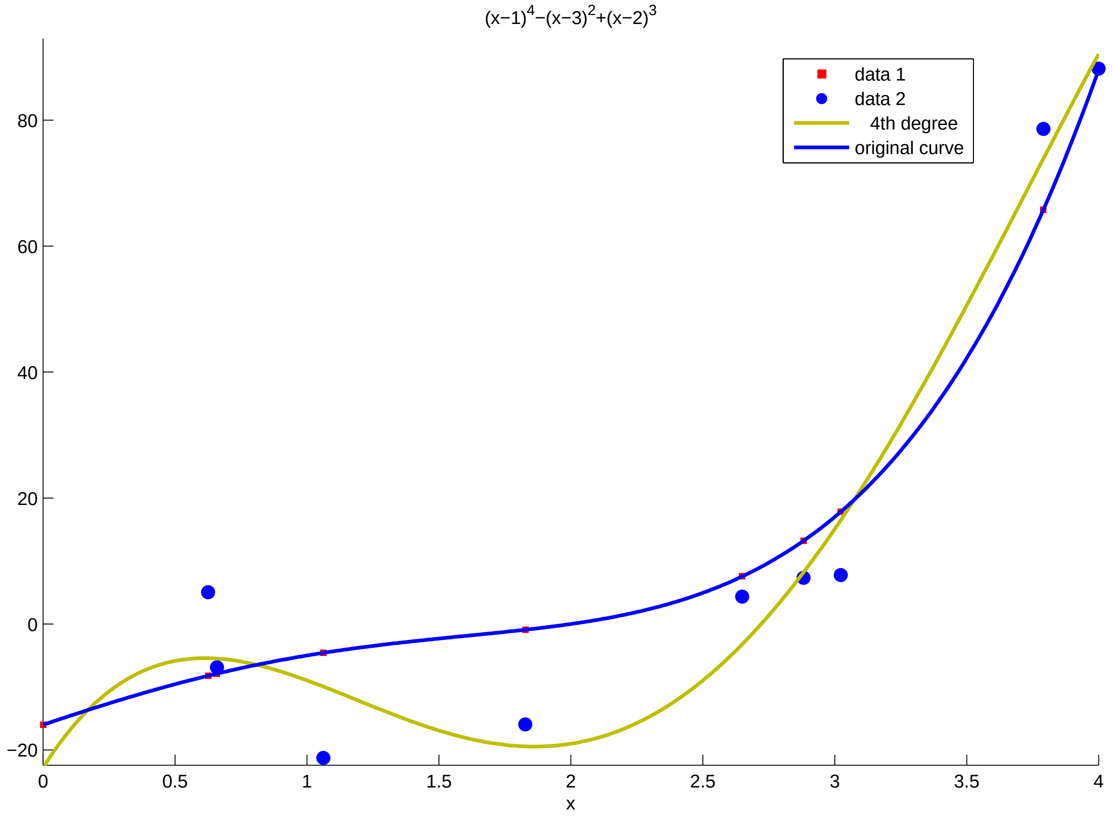
but rather an information **corrupted** by “noise”.

Things become a lot more difficult



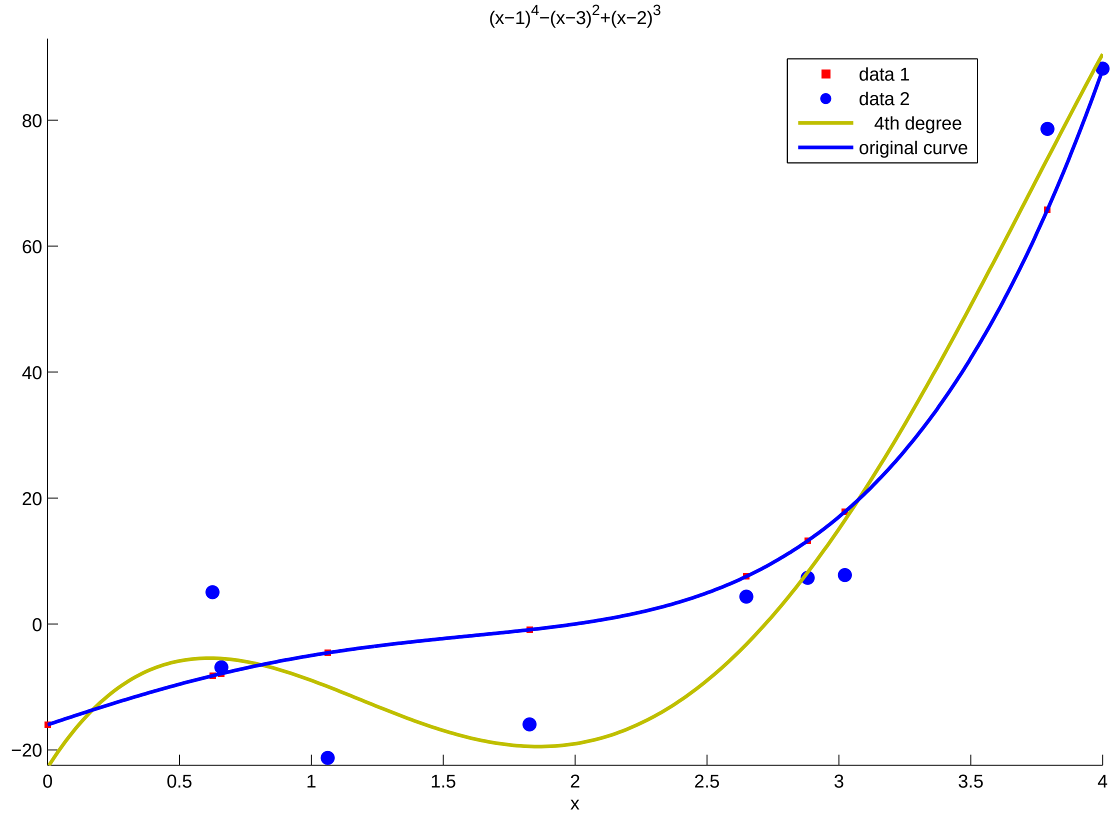
If we use standard tools...

Things become a lot more difficult



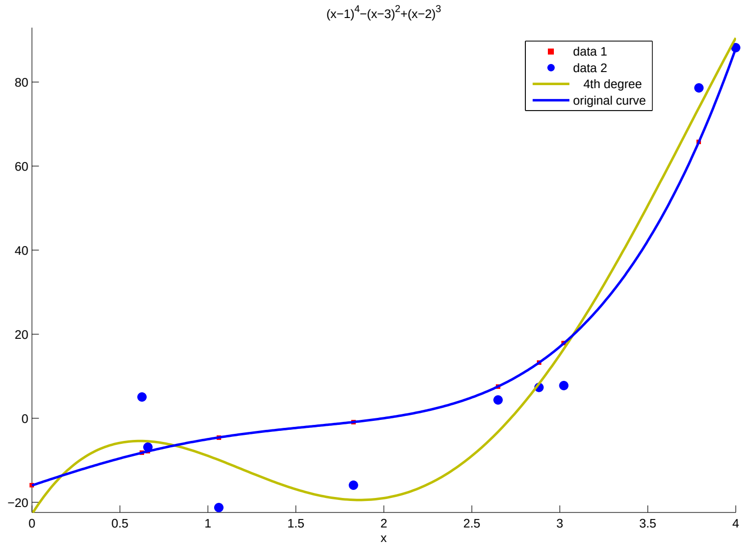
we might be very far from the original function.

Things become a lot more difficult



Can we handle **uncertainty** in a better way?
Quantify **how far** we might be from the true function?
How many points do we need to reconstruct a more **general** curve?
Does this work for surfaces in **higher dimensions**?

Things become a lot more difficult



First assignment - due Monday October 13th 23:59 by email

- Look for a definition of interpolation, *e.g.* check the wikipedia page.
- Do what I just did with Matlab and send me **an email** with the results:
  - Choose a function.. you can use fancier functions ($\sin, \cos, \exp$ *etc.*)
  - Plot it. Scatter plot a few points.
  - Use these points with the curve fitting tool. Interpolate & Compare.
- Finally: give me a hint of what might go wrong in higher dimensions?