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# Testing AI

## What makes AI testing different

Workgroup Testing and AI

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- Sander Mol – Chairman



Note: This document is automatic translated with the use of Google Translate. It may contain errors and some Dutch sayings are different in English

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**TestNet Presentation**

**17-11-20 v1.0 EN**

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## Agenda

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1. Introduction Artificial Intelligence
2. Machine Learning an explanation
3. What makes AI testing different
4. AI Test courses
5. Questions and closing

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**Testing AI**

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## Agenda

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### 1. Introduction Artificial Intelligence

- What is intelligence
  - How does something become intelligence
  - Examples of AI
- 

1. Machine Learning an explanation
  2. What makes AI testing different
  3. AI Test courses
  4. Questions and closing
- 

## Testing AI

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## The meaning of the words Artificial and Intelligence

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What is Artificial?

- Not of natural origin, but man-made or designed
- Or... is it an art?

What is Intelligence?

- There is no fixed definition of it, but rather a description of skills
- We don't know, but people are (generally)

In addition, there are several forms of intelligence, including:

- Musical
- Mathematical
- Visual
- Linguistic
- Human (inter and intra)



The Turing Test keeps coming up to determine whether "something" is Artificial Intelligence

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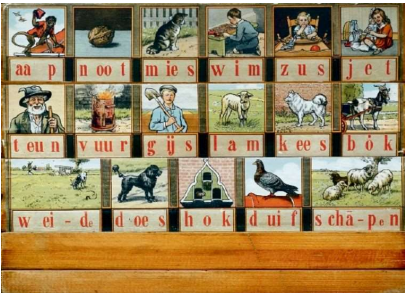
### The history of AI

Periods:	
1940 – 1960:	Early days of AI Research
1960 – 1980:	Research and Development of applications
1980 – 2000:	Boom in knowledge-based systems
AI Winter:	The development of AI has a grilling course, there are a number of periods to recognize where the development has come to a standstill
2000 – 2020:	Since 2010 there has been strong growth thanks to the success of Machine Learning techniques. This has been made possible by: <ul style="list-style-type: none"><li>• Availability of data</li><li>• Computer power</li></ul>

### Testing AI

### Intelligence and Learning

- How does a person become intelligent?
- By learning
- And how do people learn.
1. Using Examples:  
Objective: “Think of a picture book for children”
  2. Through Assumptions and Observations:  
Subjective: “Morning red, rain in the ditch”
  3. By Rewarding and Punishing:  
Fall and rise  
"If you tidy up your room now, you can go to bed later"  
"You only touch an electric fence once"  
"A donkey only hits the same stone once"



### Testing AI

### Intelligence and Learning

- How does a computer become intelligent?
- Traditional: By programming rules
  - Machine Learning: By learning to recognize patterns

When a computer itself learns something based on data (patterns), we call it **Machine Learning**.

Learning actually works in a similar way to humans:

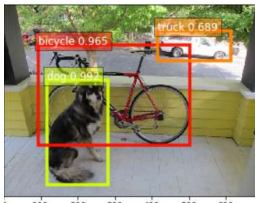
1. Using Examples:  
This is called **Supervised Learning**
2. Through Assumptions and Observations:  
This is called **UnSupervised Learning**
3. By Rewarding and Punishing:  
This is called **Reinforcement Learning**



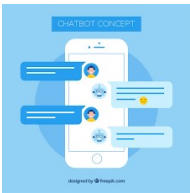
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### Examples of AI Applications

Object recognition



Chatbot



Fraud detection



Social distancing checker

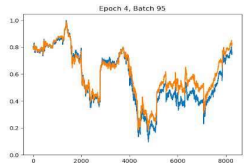


Recommender System

Vaak samen gekocht



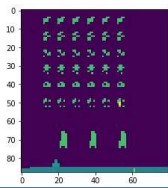
Stockprice prediction



Market analysis



RPA



### Testing AI

**The confusion: AI, Machine Learning and Deep Learning**

There is often confusion about words related to AI

There are several definitions and the terms:

- Artificial Intelligence (AI)
- Machine Learning (ML)
- Deep Learning (DL)

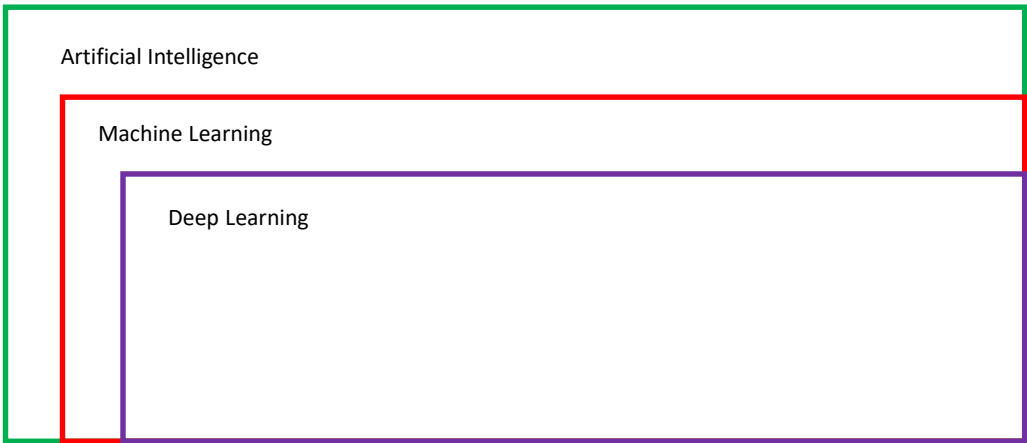
These are used interchangeably.

What does the picture look like?



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**AI, Machine Learning and Deep Learning**



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AI, Machine Learning and Deep Learning

Artificial Intelligence

We have known this for a long time.  
Think of the Turing Test (if a human can't see the distinction, then intelligently)

So with this definition, the following known systems are also covered

- Stock systems
- Planning systems
- Multiple Choice exam systems



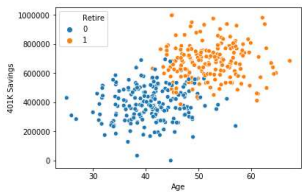
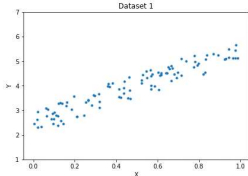
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AI, Machine Learning and Deep Learning

Artificial Intelligence

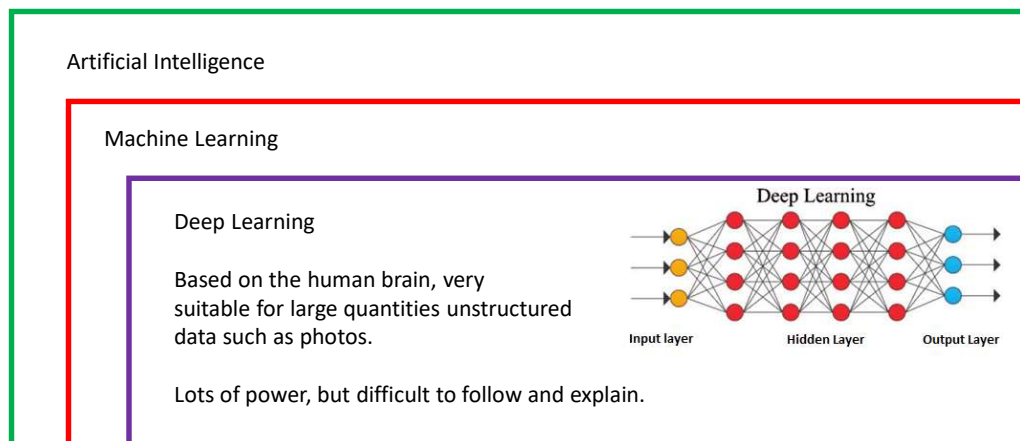
Machine Learning

It is a kind of applied statistic; it looks for patterns in the data and uses them to make predictions.



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## AI, Machine Learning and Deep Learning



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## In summary

What you must remember is that:

- Artificial Intelligence has been around for a long time and is still evolving
- Machine Learning is possible in several ways, and each option has its specific characteristics
- There are a variety of AI applications

With the result:

- There is no one-size-fits-all approach to testing AI
- AI applications are becoming more and more mature, so is the need for testing

And:

- A person can learn in different ways and has multiple intelligence forms, a computer can specialize in one type to date (and can often do this very well) but is not able to reason how the result came about.

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## Agenda

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1. Introduction Artificial Intelligence
  2. **Machine Learning an explanation**
    - What is a model
    - When do you use Machine Learning
  3. What makes AI testing different
  4. AI Test courses
  5. Questions and closing
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## Testing AI

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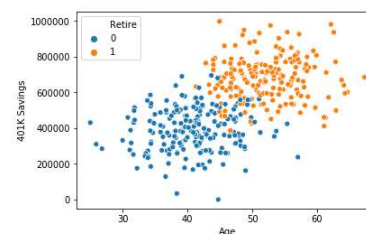
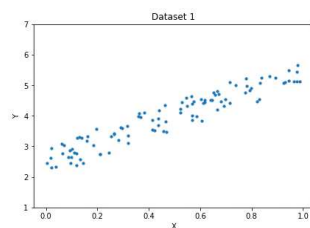
## Machine Learning an explanation

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Machine Learning is actually Applied Statistics

Machine Learning tries to recognize a pattern based on data.

- This could be a line
- This can be a division into groups



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Back to the High School

Suppose we have the following data:

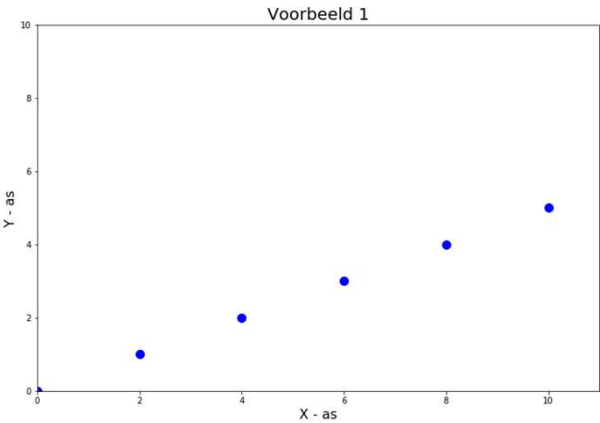
X	Y
0	0
2	1
4	2
6	3
8	4
10	5

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Back to the High School

Then you get the following graph:

X	Y
0	0
2	1
4	2
6	3
8	4
10	5

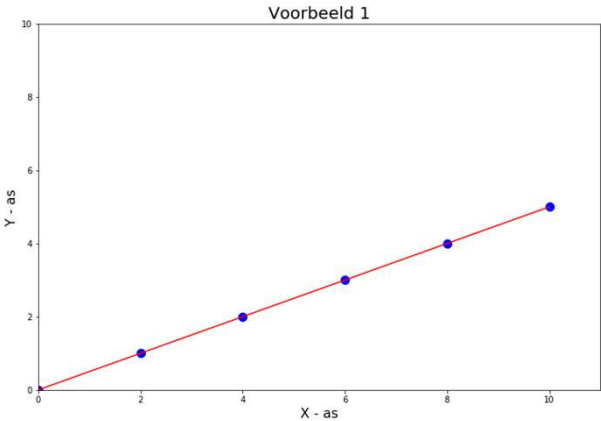


Testing AI

Back to the High School

Then you get the following graph with the following line:

X	Y
0	0
2	1
4	2
6	3
8	4
10	5

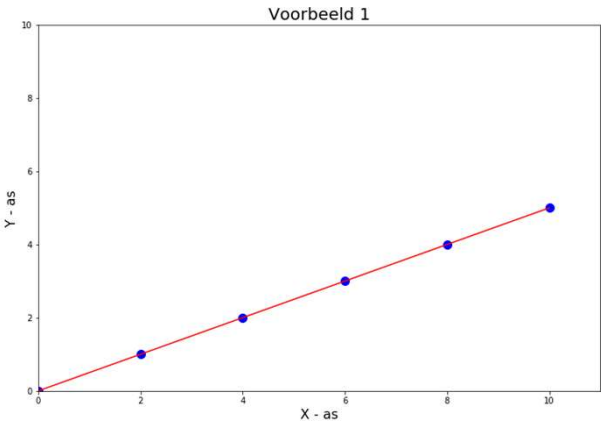


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Back to the High School

We can determine the formula for this line.

X	Y
0	0
2	1
4	2
6	3
8	4
10	5



The formula of this line is::

$Y = \frac{1}{2} * X$

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Back to the High School

Now a bit more difficult with the following data:

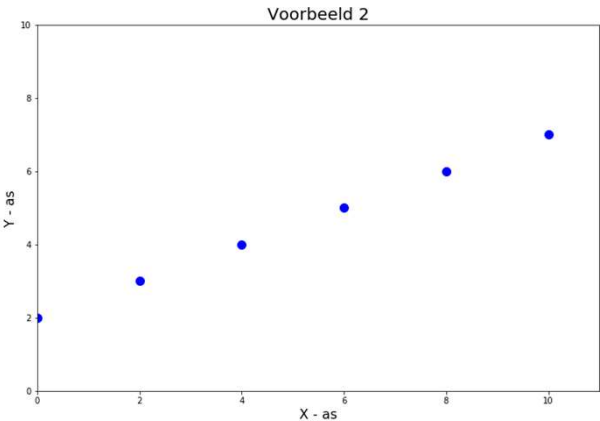
X	Y
0	2
2	3
4	4
6	5
8	6
10	7

Testing AI

Back to the High School

Then you get the following graph:

X	Y
0	2
2	3
4	4
6	5
8	6
10	7

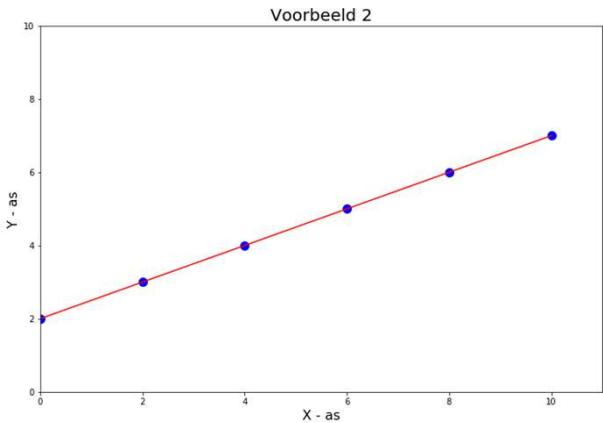


Testing AI

Back to the High School

Then you get the following graph with the following line:

X	Y
0	2
2	3
4	4
6	5
8	6
10	7

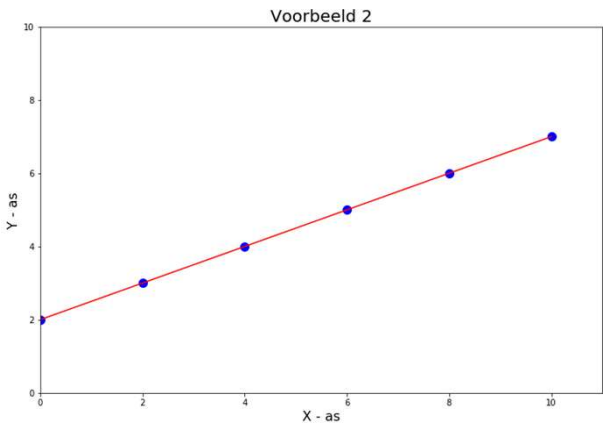


Testing AI

Back to the High School

And again we can determine the formula for this line.

X	Y
0	2
2	3
4	4
6	5
8	6
10	7



The formula of this line is:

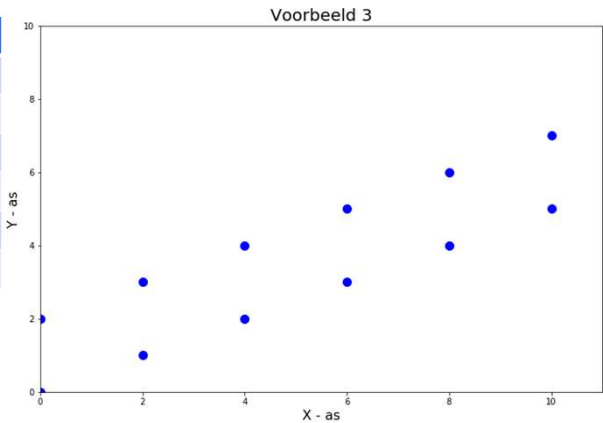
$Y = (\frac{1}{2} * X) + 2$

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Back to the High School

And now combined:

X	Y1	Y2
0	0	2
2	1	3
4	2	4
6	3	5
8	4	6
10	5	7

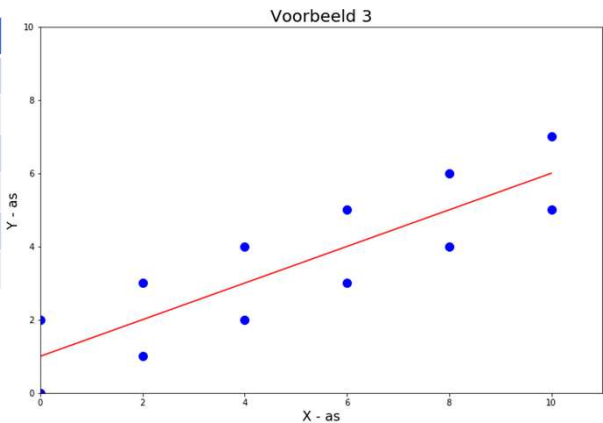


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Back to the High School

And now combined and with an optimal line (best line)

X	Y1	Y2
0	0	2
2	1	3
4	2	4
6	3	5
8	4	6
10	5	7

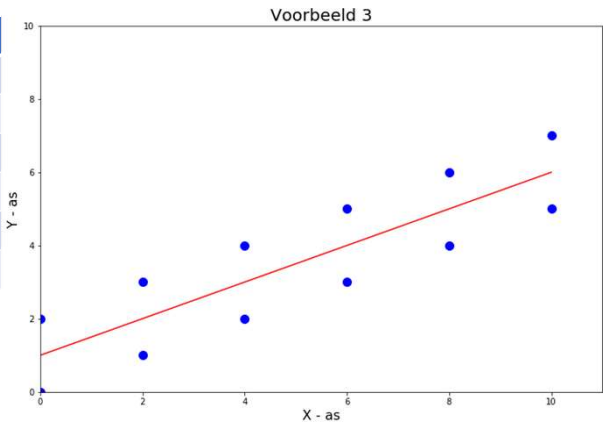


Testing AI

Back to the High School

And now combined and with an optimal line

X	Y1	Y2
0	0	2
2	1	3
4	2	4
6	3	5
8	4	6
10	5	7



The formula of this line is:

$Y = (\frac{1}{2} * X) + 1$

Testing AI

Back to the High School

- Now suppose that:
- Y: represents the Price of a house, and
  - X: the number of Rooms

X	Y1	Y2
0	0	2
2	1	3
4	2	4
6	3	5
8	4	6
10	5	7

Rooms	Houseprice 1	Houseprice 2
0	0	2
2	1	3
4	2	4
6	3	5
8	4	6
10	5	7



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Back to the High School

- Now suppose that:
- Y: represents the Price of a house, and
  - X: the number of Rooms

X	Y1	Y2
0	0	2
2	1	3
4	2	4
6	3	5
8	4	6
10	5	7

Rooms	Houseprice 1	Houseprice 2
0	0	2
2	1	3
4	2	4
6	3	5
8	4	6
10	5	7

Then the formula changes from:

$Y = (\frac{1}{2} * X) + 1$

to:

$Houseprice = (\frac{1}{2} * Room) + 1$

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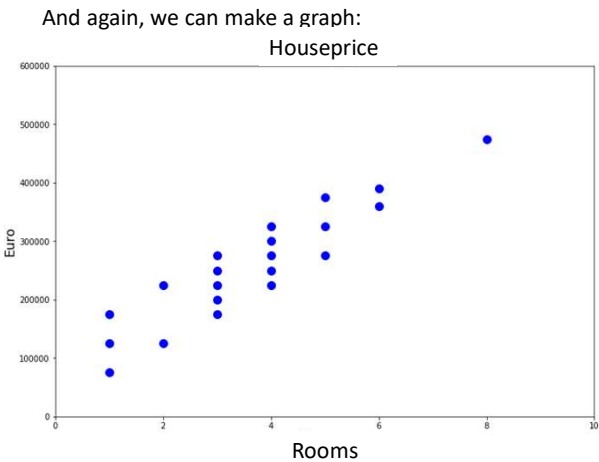
And now with Houseprice Data

Suppose we do this with more market-based data and have the following information about the number of rooms and the price of a house

Rooms	Houseprice 1	Houseprice 2	Houseprice 3	Houseprice 4	Houseprice 5
1	75.000	125.000	175.000		
2	125.000	225.000			
3	175.000	200.000	225.000	250.000	275.000
4	225.000	250.000	275.000	300.000	325.000
5	275.000	325.000	375.000		
6	360.000	390.000			
8	475.000				

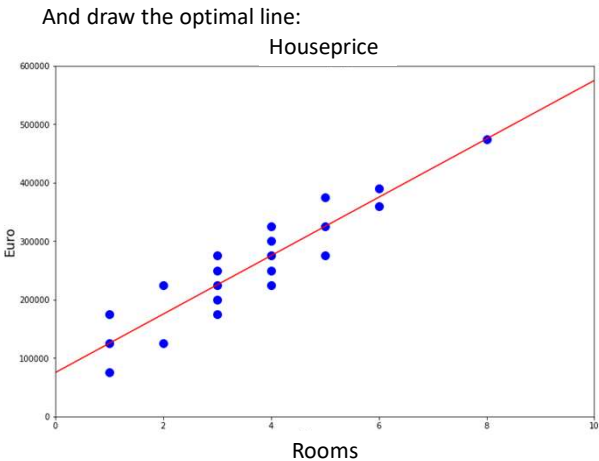
Testing AI

And now with Houseprice Data



Testing AI

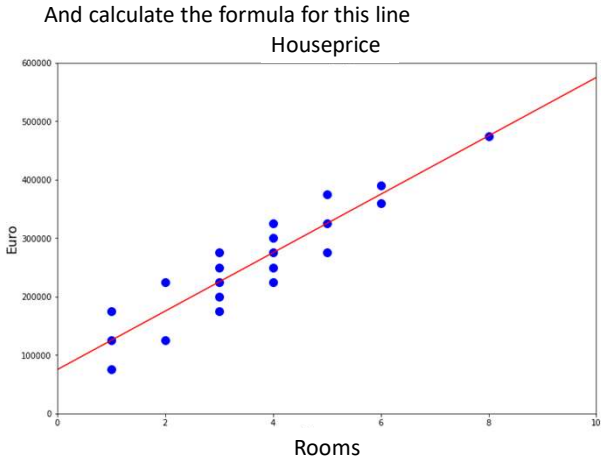
And now with Houseprice Data



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And now with Houseprice Data



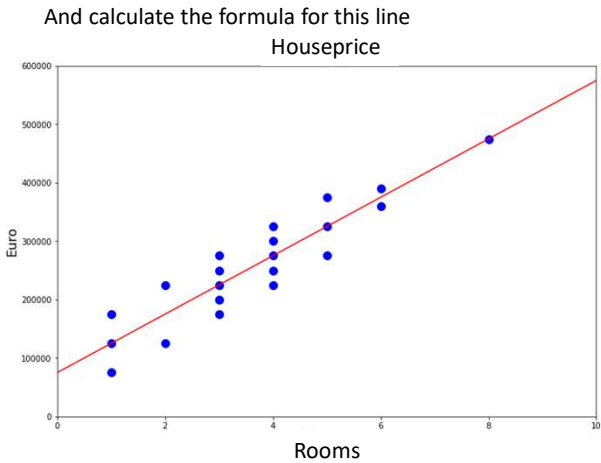
The formula for this line is:

**Houseprice = (50.000 \* Room) + 75.000**

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And now with Houseprice Data



The formula for this line is:

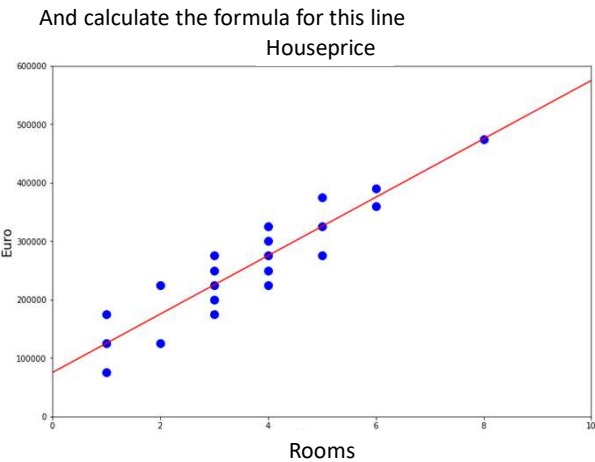
**Houseprice = (50.000 \* Room) + 75.000**

**Based on this formula, we can make a prediction of the house price.**

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And now with Houseprice Data



The formula for this line is:

**Houseprice = (50.000 \* Room) + 75.000**

**Based on this formula, we can make a prediction of the house price.**

**And this mechanism is the base for Machine Learning!**

Testing AI

Basic Machine Learning

It goes without saying that a computer based on the data:

Rooms	Houseprice 1	Houseprice 2	Houseprice 3	Houseprice 4	Houseprice 5
1	75.000	125.000	175.000		
2	125.000	225.000			
3	175.000	200.000	225.000	250.000	275.000
4	225.000	250.000	275.000	300.000	325.000
5	275.000	325.000	375.000		
6	360.000	390.000			
8	475.000				

Can determine the underlying formula: **Houseprice = (50.000 \* Room) + 75.000**

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### Basic Machine Learning

It goes without saying that a computer based on the data:

Rooms	Houseprice 1	Houseprice 2	Houseprice 3	Houseprice 4	Houseprice 5
1	75.000	125.000	175.000		
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3	175.000	200.000	225.000	250.000	275.000
4	225.000	250.000	275.000	300.000	325.000
5	275.000	325.000	375.000		
6	360.000	390.000			
8	475.000				

Can determine the underlying formula: **Houseprice = (50.000 \* Room) + 75.000**

Machine Learning is: Determine the underlying formula

This formula is called: the **Model**

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### Basic Machine Learning

However, the house price will not depend on the number of rooms alone.

The following data will certainly influence the price of a house:

- Surface,
- Garden,
- Garage,
- And certainly more!
- Detached,
- Construction year,
- Neighbourhood,

And then the power of Machine Learning emerges:

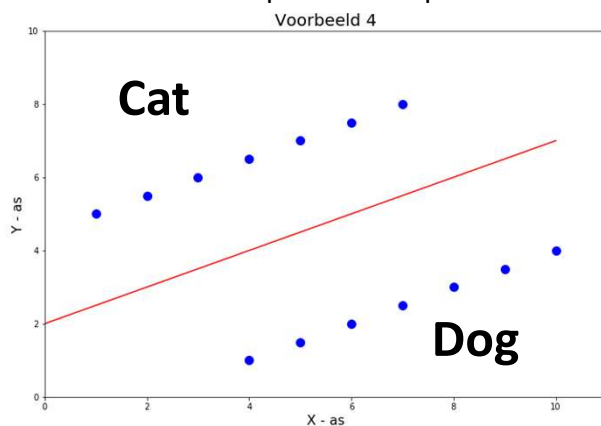
- We can still draw and understand two dimensions, such as number of rooms and house price
- Three dimensions, number of rooms, surface and house price, already requires spatial insight
- We cannot draw more dimensions! En dan komt de kracht van Machine Learning naar voren:

A computer has no problem with that, but the result is usually not easy to understand!

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## You can of course also divide them into groups

With this technique it is also possible to make a division into groups.



The line is now a boundary line.

This is called classification.

For example:

- Below the line is a dog
- Above the line is a cat

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## When do you use Machine Learning

If you want to compare Apples and Pears !!  
( Apples and Oranges )

You cannot record this in formal rules such as::

- If (Color == Yellow) then Apple else Pear
- If (Length < 6 cm) then Apple else Pear
- ... And many more rules

However, it is quite easy to solve this with AI and a lot  
Of photos of Apples and Pears.

However:

- The result is a probability of an Apple,
- And therefore not a **100% certainty!**



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Agenda

- 1. Introduction Artificial Intelligence
- 2. Machine Learning an explanation
- 3. **What makes AI testing different**
  - Data risk
  - Ethics
- 4. AI Test courses
- 5. Questions and closing

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Agenda

- 1. Introduction Artificial Intelligence
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- ~~3. **What makes AI testing different**~~
  - Data risk
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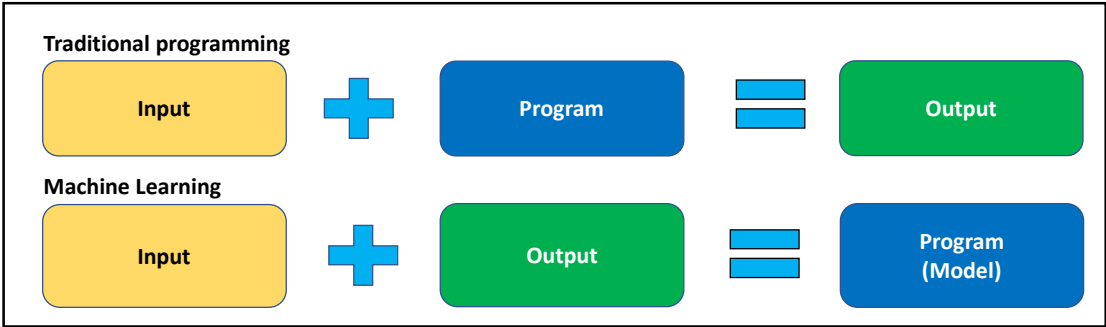
Agenda

1. Introduction Artificial Intelligence
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3. What makes Machine Learning testing different
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What makes Machine Learning testing different

The difference between Traditional Programming and Machine Learning



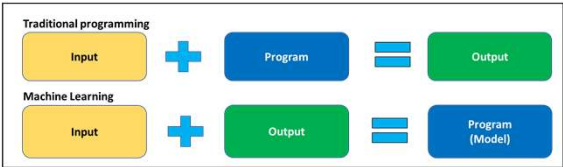
You then use the Model to make predictions

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What makes Machine Learning testing different

With traditional software systems, an analysis of the process can be used to indicate what is a good or bad result.

For this reason you can also say when a test is successful or has resulted in a defect



Compare the testing of ML systems with non-ML systems:

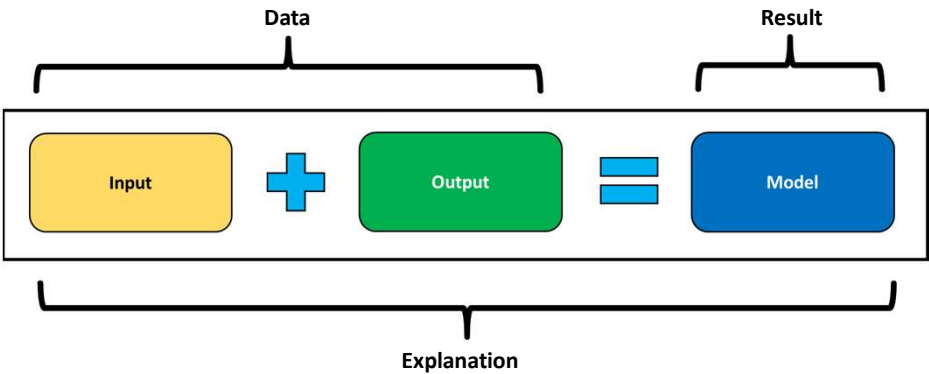
- Hard business rules and specifications are not available with ML systems
- The output of an ML system has probabilities
- The result with the same input does not always have to yield the same result
- Due to the lack of a predefined algorithm, the logic cannot be used for further analysis
- The data is crucial, the data determines the operation of the model (program)
- In AI systems, monitoring in production is (even) more important

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Focus areas for Machine Learning Testing

When testing ML you can distinguish the following areas:

1. Data
2. Result
3. Explanation

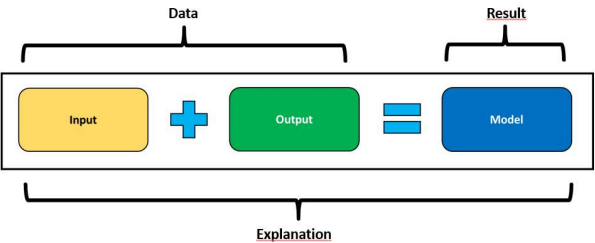


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Focus areas for Machine Learning Testing

When testing ML you can distinguish the following areas:

- 1. Data
- 2. Result
- 3. Explanation



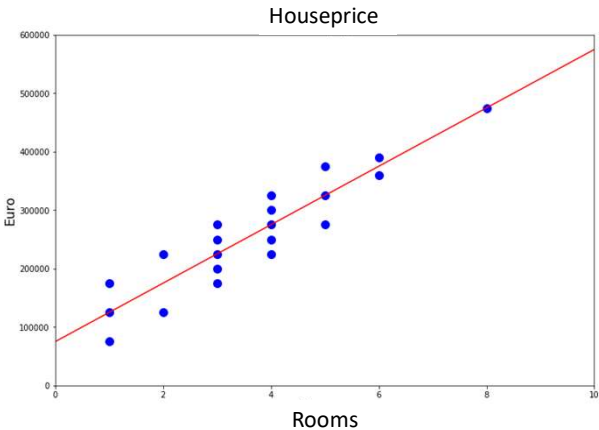
All these areas are worth a presentation of their own!

In this presentation we focus on a few Data-related aspects.

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Data related aspects

Take another look at the House Price model



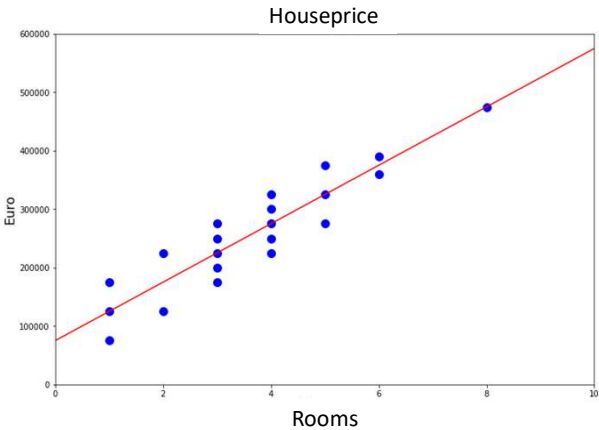
- Questions:
- Which data do you use: Land Registry, Taxes, House Selling Sites?
  - How many years do you go back, 1, 2, 5 years
  - {and how long will the model remain reliable}

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Data related aspects

Take another look at the House Price model

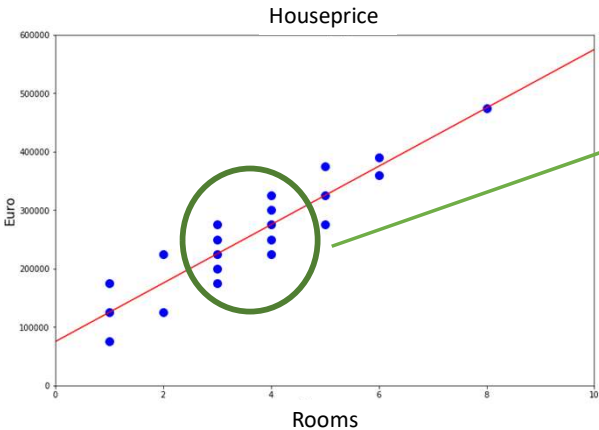


- Remarks:
- What impact does a market change have? Due to the Covid crisis, there is more demand for houses with a garden and office.
  - Keep in mind that a small change to the model, for example adding an extra field such as area, immediately results in a 100% new model.

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Data related aspects

Take another look at the House Price model

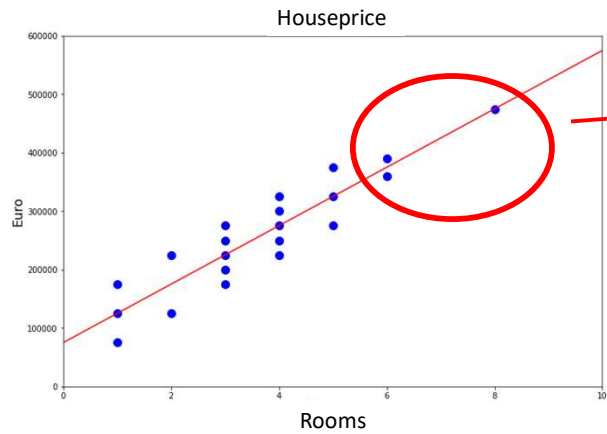


More data from 3 and 4 room houses, so better substantiation and reliability

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Data related aspects

Take another look at the House Price model

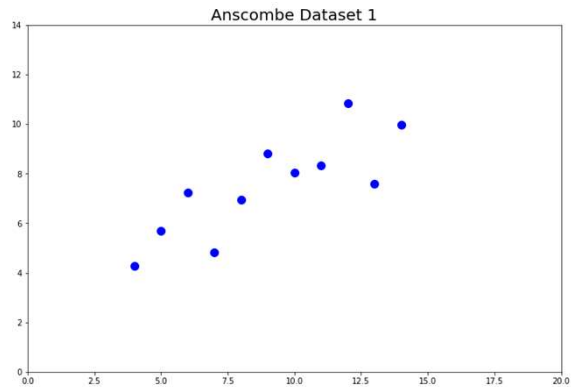


- Little data from 6 and more room houses, how reliable is the model for these houses
- No data for a house with 7 rooms, can you make a prediction for this?
- Are you allowed to make a prediction for a house with more than 8 rooms, data is totally missing

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Data related aspects

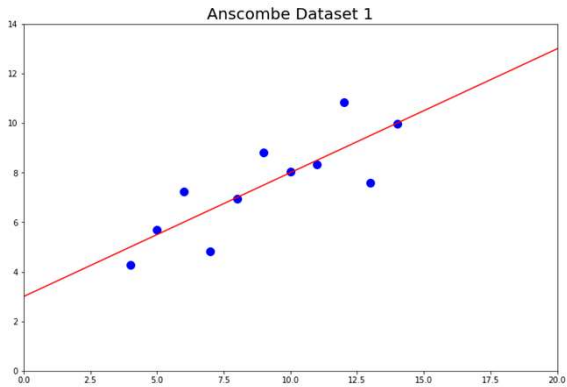
And look at this example:



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Data related aspects

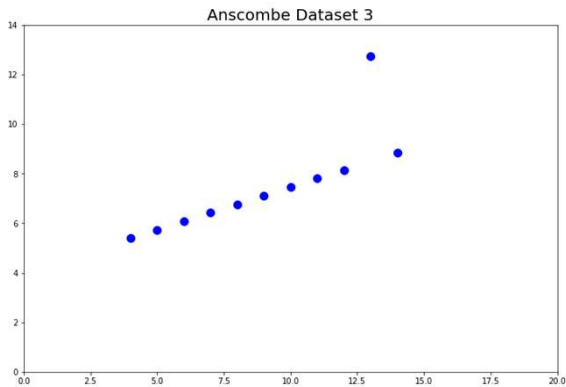
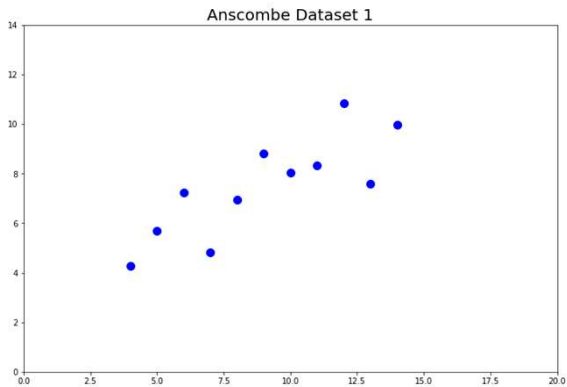
And look at this example:



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Data related aspects

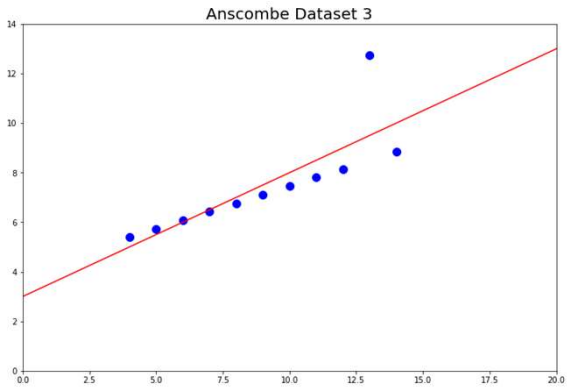
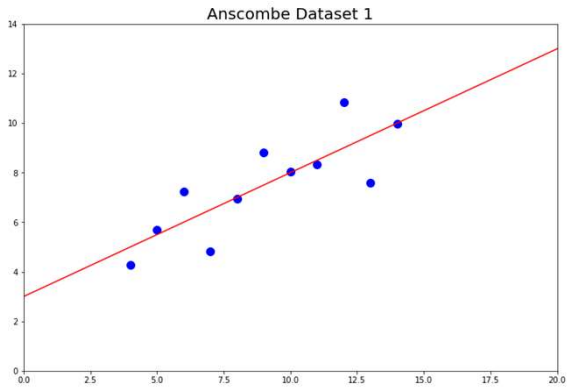
Compare this with another dataset and see the differences



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Data related aspects

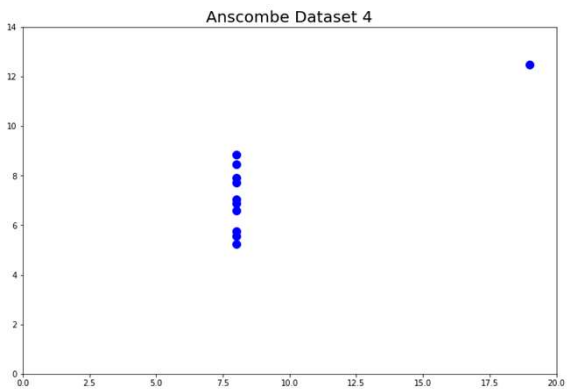
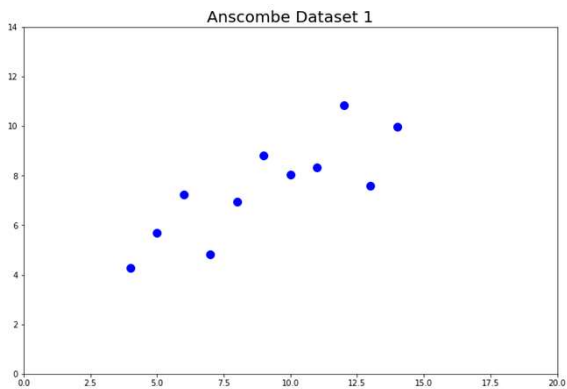
However, they have the same model!



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Data related aspects

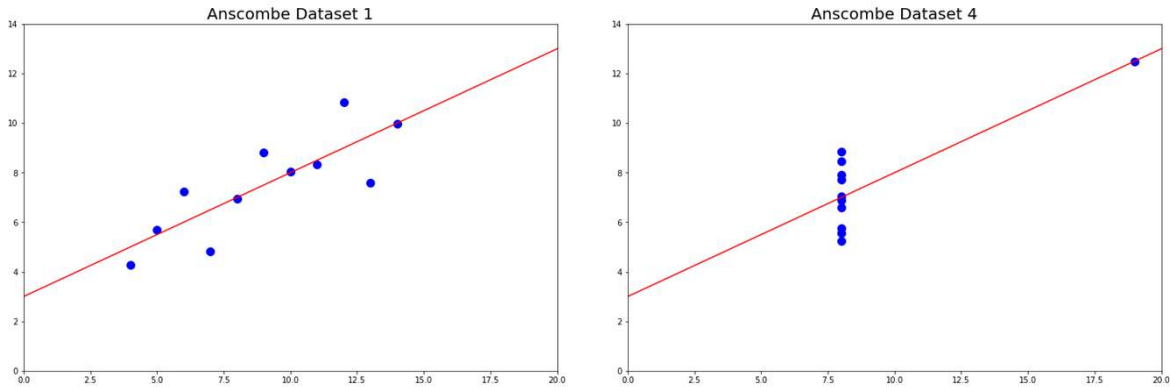
And another comparison with another dataset with a different pattern



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Data related aspects

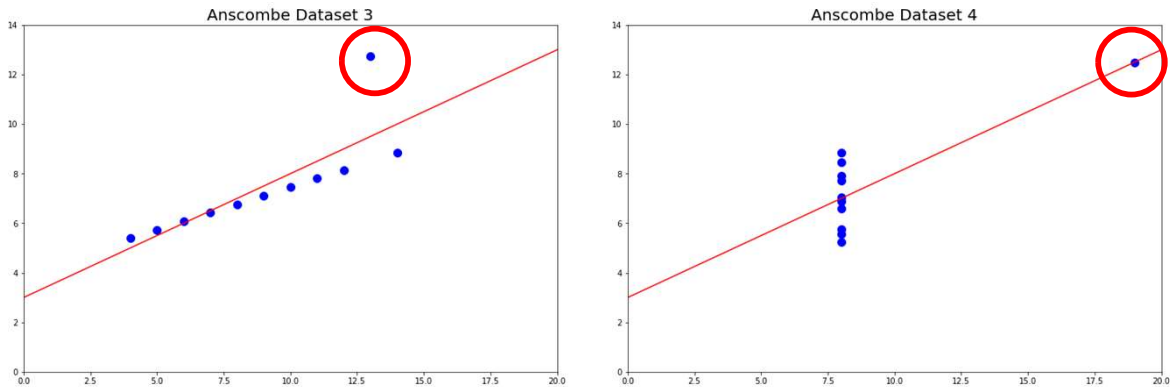
And again with the same model!



Testing AI

Data related aspects

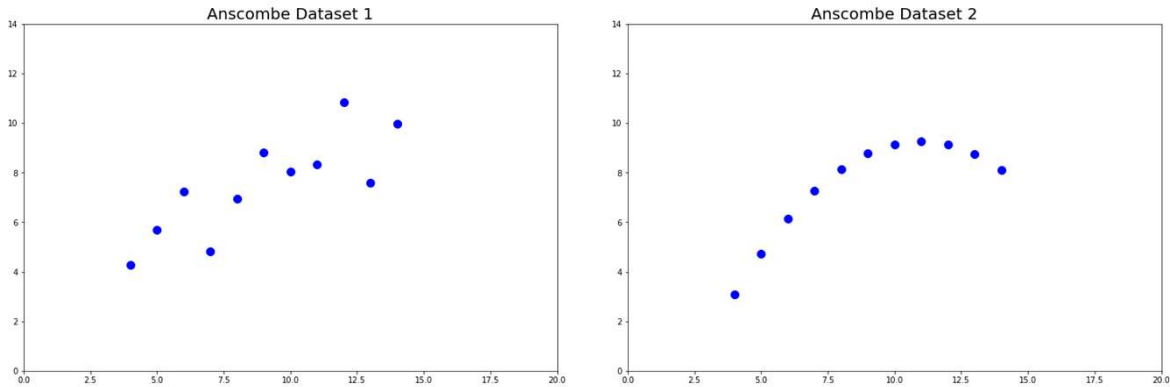
These strange models are caused by Outliers in the Data



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Data related aspects

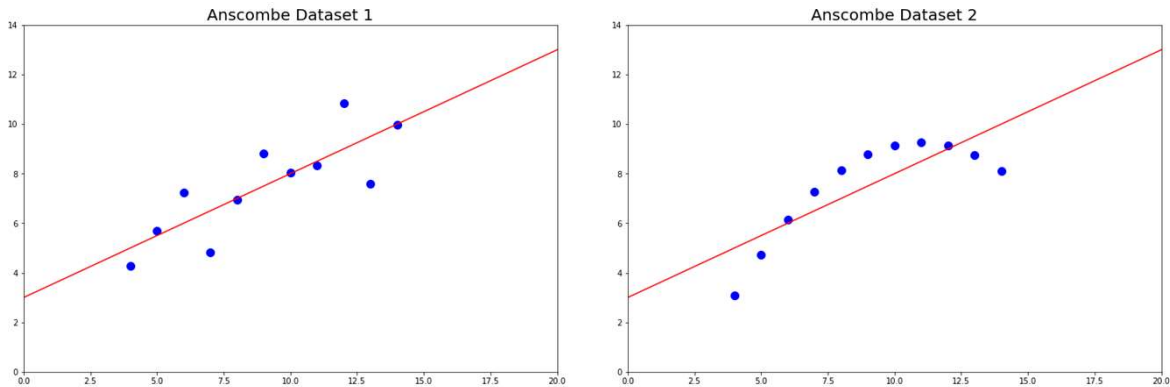
And to make the picture complete, this is also possible!



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Data related aspects

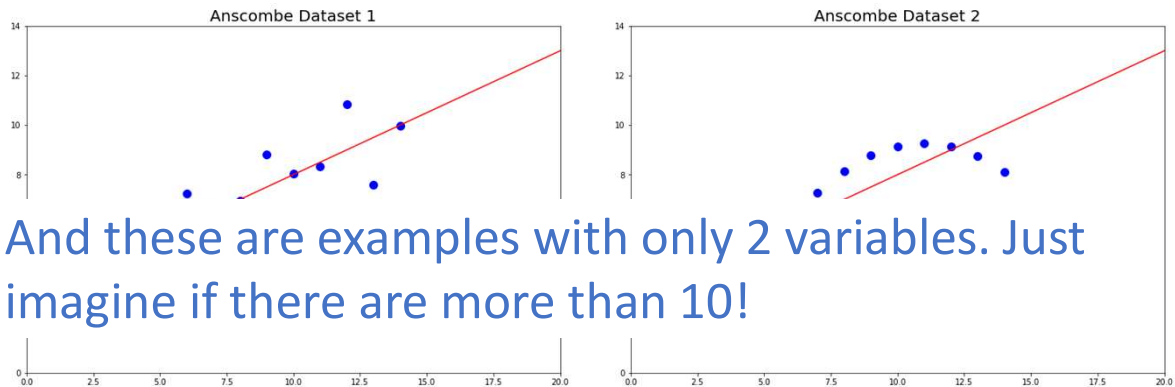
These strange models are caused by Outliers in the Data



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## Data related aspects

These strange models are caused by Outliers in the Data



And these are examples with only 2 variables. Just imagine if there are more than 10!

## Testing AI

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## AI and Ethics

As technology becomes more autonomous, takes over more decisions and the decision rules are more difficult to trace, new ethical issues arise. Previously, ethics was mainly about human action. However, with the advent of AI, a new player has entered the game, namely machine learning technology.

Source: "AI no longer has a plug", Rudy van Belkom

**Fairness, Bias, Transparency, Explainability, and Privacy** are all ethical characteristics and become new quality characteristics. A tester can play a role in analyzing and evaluating them.

These characteristics are necessary to gain confidence in a model.

**Trust is necessary for acceptance!**

## Testing AI

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## Summary: What makes AI testing different

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1. The question is actually: What makes Machine Learning (ML) testing different
2. Hard business rules and specifications are not available with ML systems
3. The outcome of an ML system has probabilities
4. Due to the lack of a predefined algorithm, the logic cannot be used for further analysis
5. When testing ML you can distinguish the following areas:
  - Data
  - Result
  - Explanation
6. A tester can play an important role in gaining trust and thus in the acceptance of ML solutions

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## Agenda

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1. Introduction Artificial Intelligence
2. Machine Learning an explanation
3. What makes AI testing different
4. **AI Test courses**
  - A4Q
  - Ai United
  - Positioning and recommended prior knowledge
5. Questions and closing

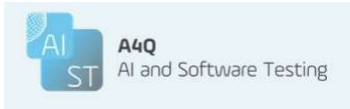

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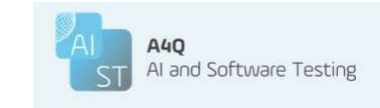



Overview of AI Test courses

AI Test courses with a Syllabus:	
	A4Q AI and Software Testing <a href="https://www.alliance4qualification.info/a4q-ai-and-software-testing">https://www.alliance4qualification.info/a4q-ai-and-software-testing</a>
	AiU Certified Tester in AI (CTAI) <a href="https://www.ai-united.org/">https://www.ai-united.org/</a>

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Overview of AI Test courses

	
<b>Target audience:</b> <ul style="list-style-type: none"><li>• Focuses on the tester who encounters AI in an environment with other systems</li></ul>	<b>Target audience:</b> <ul style="list-style-type: none"><li>• Focuses on the tester who wants to test the operation of the AI model in all phases of the process.</li></ul>
<b>Level:</b> <ul style="list-style-type: none"><li>• Comparable to ISTQB Foundation levels</li></ul>	<b>Level:</b> <ul style="list-style-type: none"><li>• More towards the ISTQB Advanced (Technical) levels</li></ul>
<b>Recommendation:</b> <ul style="list-style-type: none"><li>• Some insight in advance into how AI works</li></ul>	<b>Recommendation:</b> <ul style="list-style-type: none"><li>• Some insight in advance into how AI works</li><li>• Hands-On experience in modeling</li><li>• Use the A4Q training as a foundation exam</li></ul>

Testing AI

**Agenda**

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- 1. Introduction Artificial Intelligence
  - 2. Machine Learning an explanation
  - 3. What makes AI testing different
  - 4. AI Test courses
  - 5. Questions and closing**
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**Testing AI**

**Questions and Closing**

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- Questions:
- \_\_\_\_\_?
  - \_\_\_\_\_?
  - \_\_\_\_\_?

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**Contact information:**

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- Contact us:
- For questions regarding this presentation
  - General questions about testing AI
  - For information about the working group,
  - Tips and other advice
  - Other comments

Peter Collewyn: [Peter@Collewijn.nl](mailto:Peter@Collewijn.nl)  
Sander Mol: [Sander.Mol@Salves.nl](mailto:Sander.Mol@Salves.nl)

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**Sources:**

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- A4Q AI and Software Testing: <https://www.alliance4qualification.info/a4q-ai-and-software-testing>
- AiU Certified Tester in AI (CTAI): <https://www.ai-united.org/>
- De Nationale AI-Cursus:  
(National AI Course) <https://app.ai-cursus.nl/home>
- De Toekomst van AI:  
(The Future of AI) <https://detoekomstvanai.nl/>
- Anscombe's Quartet: [https://en.wikipedia.org/wiki/Anscombe%27s\\_quartet](https://en.wikipedia.org/wiki/Anscombe%27s_quartet)

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