Process Mining: Data Science in Action

How Process Mining Relates to Data Mining

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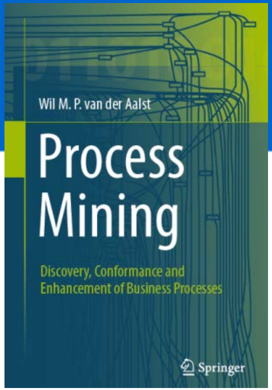
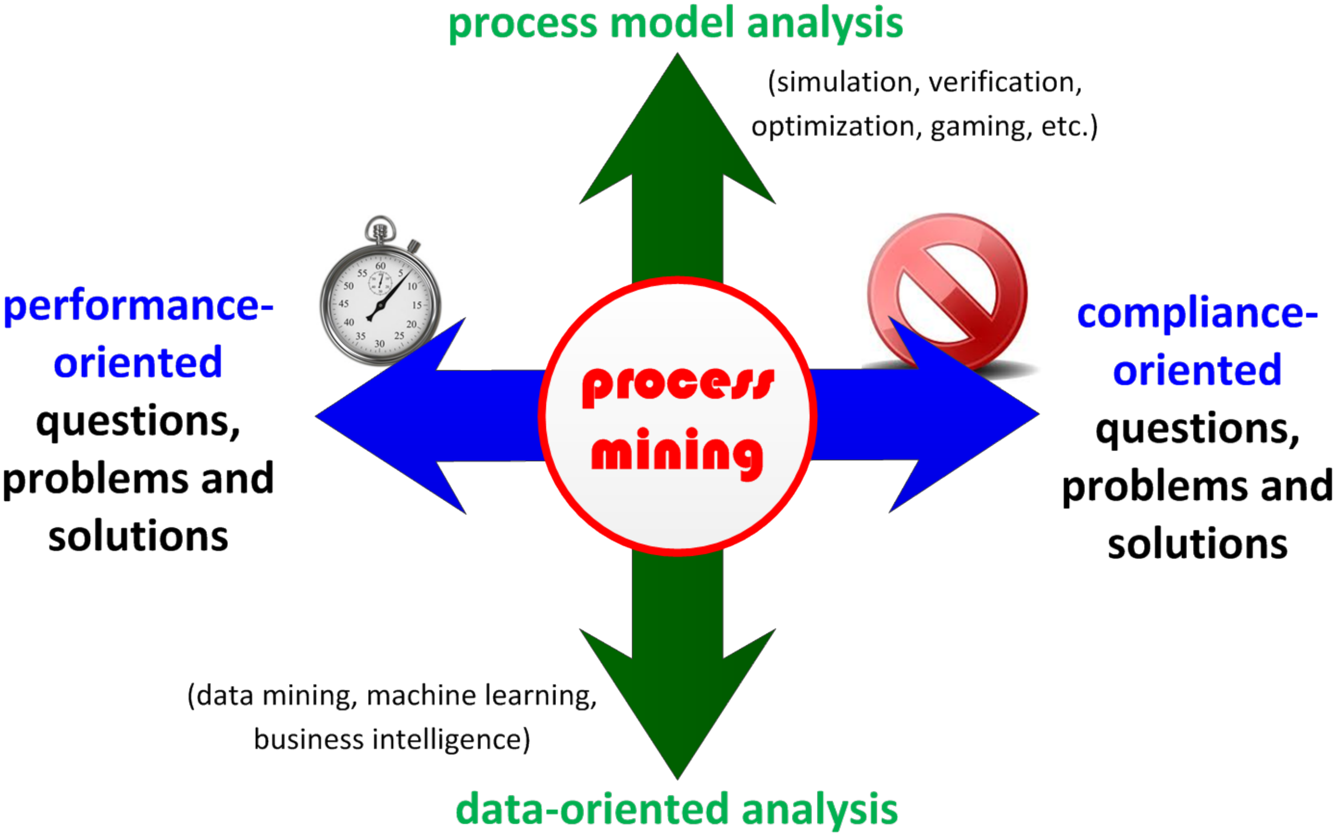
www.processmining.org



TU/e Technische Universiteit Eindhoven University of Technology

Where innovation starts

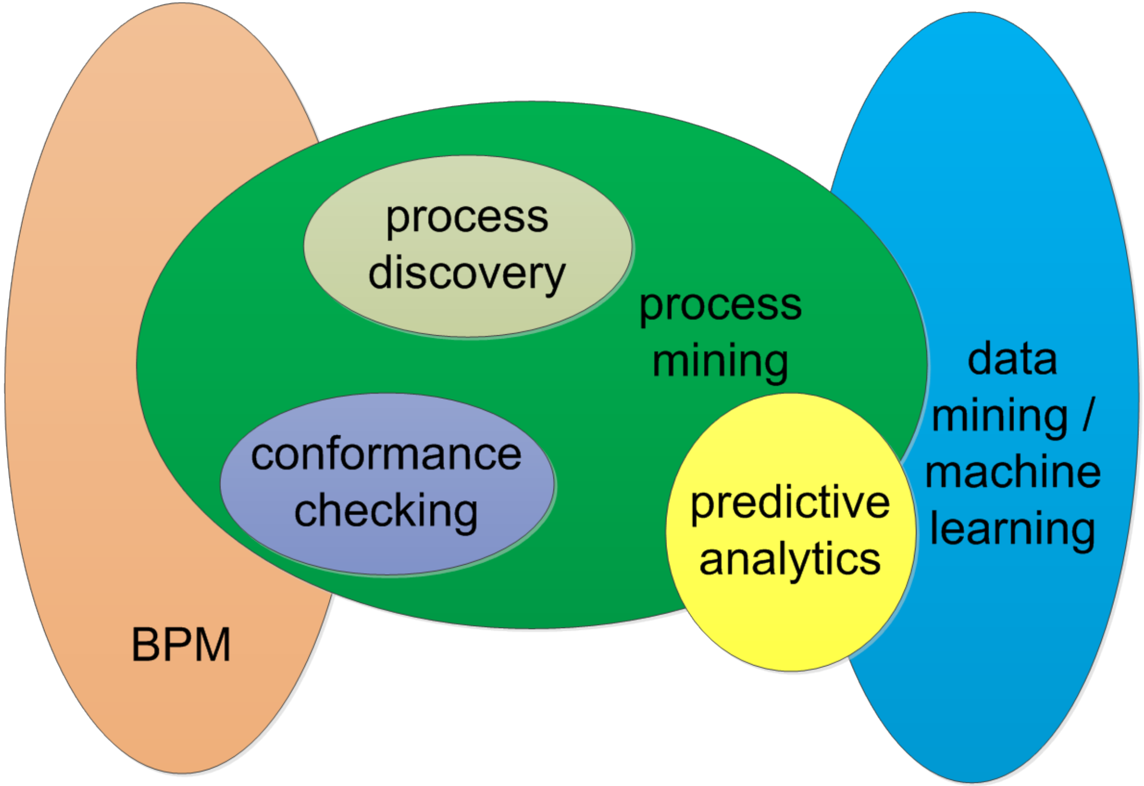
Process mining: The missing link



Connecting things: Process mining as super glue

- **Data – Process**
- **Business – IT**
- **Business Intelligence – Business Process Management**
- **Performance – Compliance**
- **Runtime – Design time**
- **…**

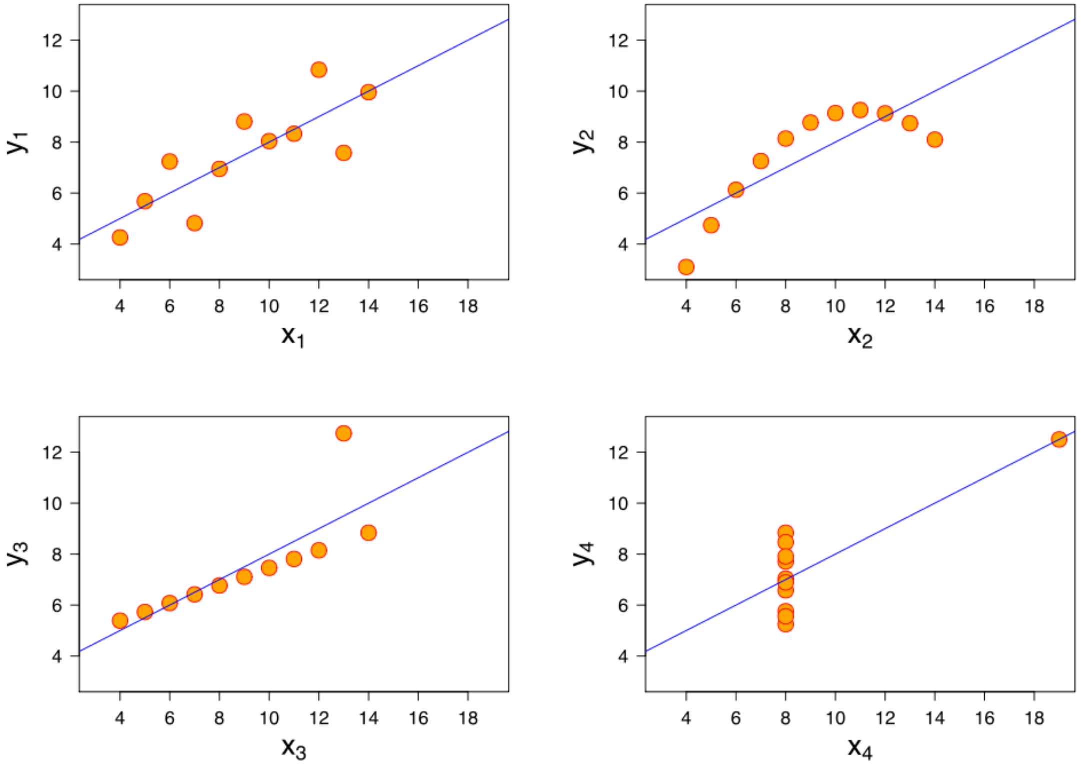
Positioning Process Mining



How about BI (Business Intelligence)?

Don't try to capture reality in a simple KPI!

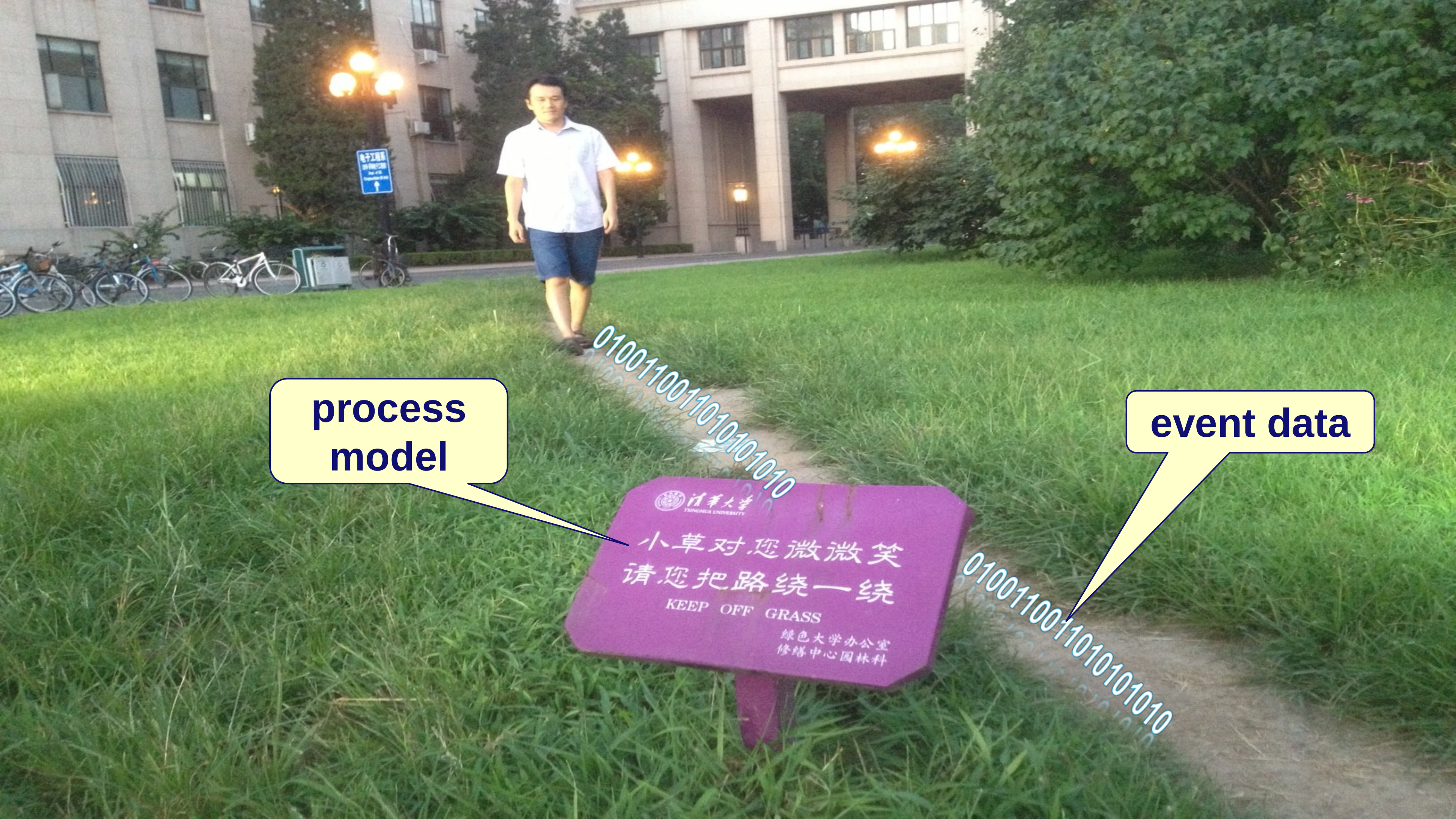
(Like BI tools do)



4 data sets of
11 elements

Anscombe's Quartet

mean x = 9
variance x = 11
mean y = 7.5
variance y = 4.12
correlation = 0.816
same linear regression


process model
event data
清華大学
TSINGHUA UNIVERSITY
小草对您微微笑
请您把路绕一绕
KEEP OFF GRASS
绿色大学办公室
修缮中心园林科

Picture by Koen Olsthoorn


Demo

Process discovery is like learning a language: By example

abc ?

ab(c|d) ?

(ad)|(ab(c|d)) ?

ab*(c|d) ?

abc

abd

ad

abbc

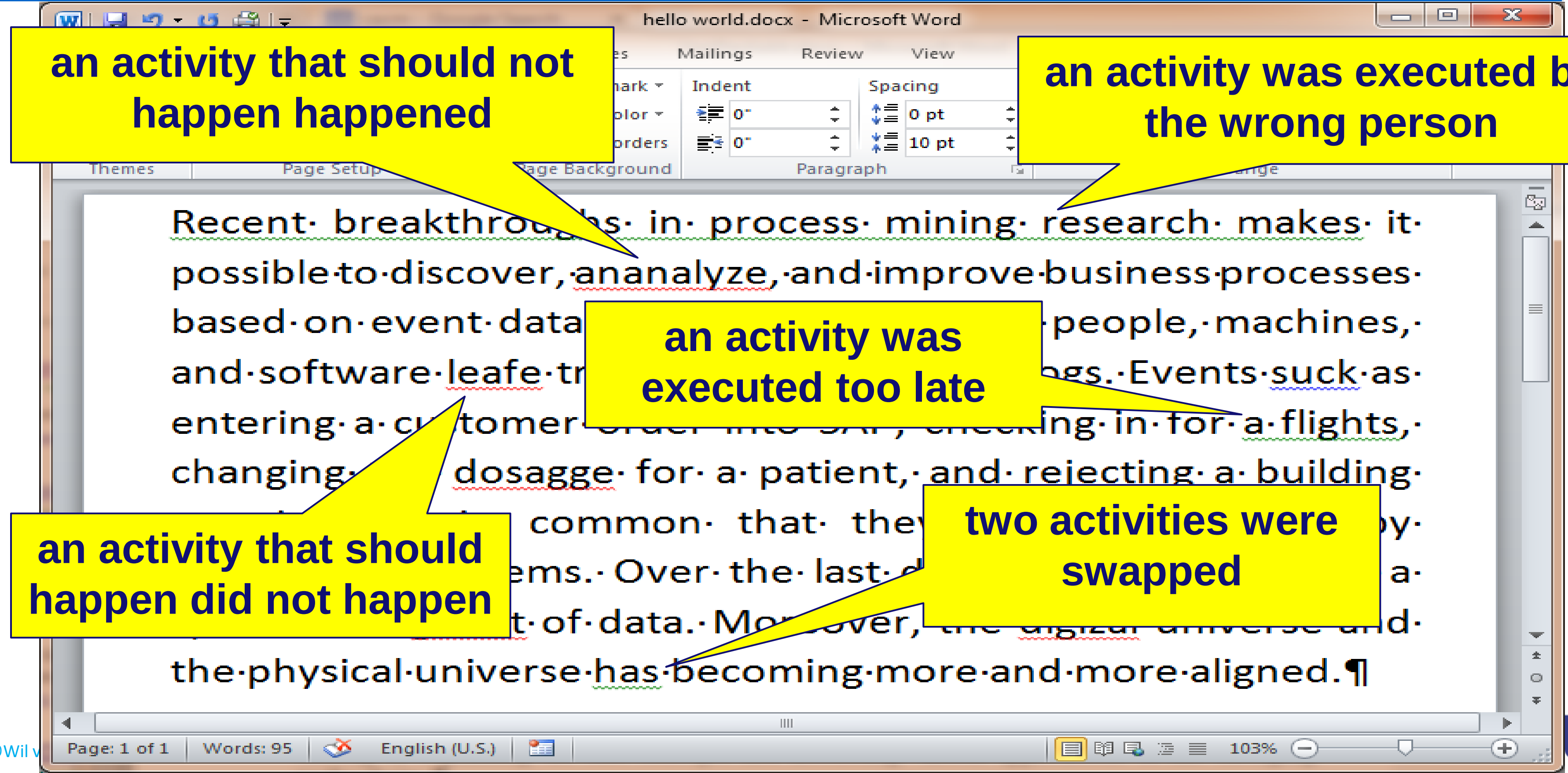
ac

…

sentence ≅ trace in event log

language ≅ process model

Conformance checking is like spell checking




Data Mining
Straight Ahead

Data mining

- The growth of the “digital universe” is the main driver for the popularity of data mining.
- Initially, the term “data mining” had a negative connotation (“data snooping”, “fishing”, and “data dredging”).
- Now a mature discipline.
- Data-centric, not process-centric.

Data set 1

Data about 860 recently deceased persons to study the effects of drinking, smoking, and body weight on the life expectancy.

drinker	smoker	weight	age
yes	yes	120	44
no	no	70	96
yes	no	72	88
yes	yes	55	52
no	yes	94	56

Questions:

- What is the effect of smoking and drinking on a person's bodyweight?
- Do people that smoke also drink?
- What factors influence a person's life expectancy the most?
- Can one identify groups of people having a similar lifestyle?

Data set 2

Data about 420 students to investigate relationships among course grades and the student's overall performance in the Bachelor program.

linear algebra	logic	program-ming	operations research	workflow systems	...	duration	result
9	8	8	9	9	...	36	cum laude
7	6	-	8	8	...	42	passed
-	-	5	4	6	...	54	failed
8	6	6	6	5	...	38	passed

Questions:

- Are the marks of certain courses highly correlated?
- Which electives do excellent students (cum laude) take?
- Which courses significantly delay the moment of graduation?
- Why do students drop out?
- Can one identify groups of students having a similar study behavior?

Data set 3

Data on 240 customer orders in a coffee bar recorded by the cash register.

cappuccino	latte	espresso	americano	ristretto	tea	muffin	bagel
1	0	0	0	0	0	1	0
0	2	0	0	0	0	1	1
0	0	1	0	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	1	2	0
0	0	0	1	1	0	0	0
							...

Questions:

- **Which products are frequently purchased together?**
- **When do people buy a particular product?**
- **Is it possible to characterize typical customer groups?**
- **How to promote the sales of products with a higher margin?**

Variables

- Data set (sample or table) consists of instances (individuals, entities, cases, objects, or records).
- Variables are often referred to as attributes, features, or data elements.
- Two types:
  - categorical variables:
    - ordinal (high-med-low, cum laude-passed-failed) or
    - nominal (true-false, red-pink-green)
  - numerical variables (ordered, cannot be enumerated easily)

Question

drinker	smoker	weight	age
yes	yes	120	44
no	no	70	96
yes	no	72	88
yes	yes	55	52
no	yes	94	56

There are four variables:

- **Which ones are ordinal categorical variables?**
- **Which ones are nominal categorical variables?**
- **Which ones are numerical variables?**

Answer

drinker	smoker	weight	age
yes	yes	120	44
no	no	70	96
yes	no	72	88
yes	yes	55	52
no	yes	94	56
no	no	62	93

- **There are two categorical variables: drinker and smoker. Both are nominal.**
- **There are two numerical variables: weight and age.**

Supervised Learning

- Labeled data, i.e., there is a response variable that labels each instance.
- Goal: explain response variable (dependent variable) in terms of predictor variables (independent variables).

Supervised Learning

- **Classification techniques** (e.g., decision tree learning) assume a categorical response variable and the goal is to classify instances based on the predictor variables.
- **Regression techniques** assume a numerical response variable. The goal is to find a function that fits the data with the least error.

Question

drinker	smoker	weight
yes	yes	120
no	no	70
yes	no	72
yes	yes	55
no	yes	94
no	no	62
...	...	...

We would like to learn the influence of drinking and smoking on someone's body weight. What are the response and predictor variables?

Answer

drinker	smoker	weight
yes	yes	120
no	no	70
yes	no	[illegible]
[illegible]	[illegible]	[illegible]
no	yes	94
no	no	62
...	...	...

predictor variable

predictor variable

response variable

Unsupervised Learning

- Unsupervised learning assumes unlabeled data, i.e., the variables are not split into response and predictor variables.
- Examples: clustering (e.g., k-means clustering and agglomerative hierarchical clustering) and pattern discovery (association rules)

Data Mining Tools

- **RapidMiner** (rapidminer.com, partly commercial)
- **R** (r-project.org, free)
- **Weka** (www.cs.waikato.ac.nz/ml/weka/, GNU)
- **KNIME** (knime.org, partly commercial)
- **SAS** (sas.com, commercial)
- **IBM**
- **IBM**
- **QlikView** (qlikview.com, commercial)
- **SAP BusinessObjects/HANA** (www.sap.com/pc/analytics/, commercial)

We will use RapidMiner to illustrate classical data mining techniques.

Process Mining Versus Data Mining

- Both start from data.
- Data mining techniques are typically not process-centric.
- Topics such as process discovery, conformance checking, and bottleneck analysis are not addressed by traditional data mining techniques.

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Process Mining Versus Data Mining

- **End-to-end** process models and **concurrency** are essential for process mining.
- Process mining assumes event logs where events have **timestamps** and refer to **cases** (process instances).
- Process mining and data mining need to be **combined** for more advanced questions.

Part I: Preliminaries

Chapter 1 Introduction

Chapter 2 Process Modeling and Analysis

Chapter 3 Data Mining

Part II: From Event Logs to Process Models

Chapter 4 Getting the Data

Chapter 5 Process Discovery: An Introduction

Chapter 6 Advanced Process Discovery Techniques

Part III: Beyond Process Discovery

Chapter 7 Conformance Checking

Chapter 8 Mining Additional Perspectives

Chapter 9 Operational Support

Part IV: Putting Process Mining to Work

Chapter 10 Tool Support

Chapter 11 Analyzing “Lasagna Processes”

Chapter 12 Analyzing “Spaghetti Processes”

Part V: Reflection

Chapter 13 Cartography and Navigation

Chapter 14 Epilogue