


Data Representation

The popular table

- Table (relation)
  - propositional, attribute-value
- Example
  - record, row, instance, case
  - independent, identically distributed
- Table represents a sample from a larger population
- Attribute
  - variable, column, feature, item
- Target attribute, class
- Sometimes rows and columns are swapped
  - bioinformatics

A	B	C	D	E	F
…	…	…	…	…	…
…	…	…	…	…	…
…	…	…	…	…	…

Example: symbolic weather data

Outlook	Temperature	Humidity	Windy	Play
sunny	hot	high	false	no
sunny	hot	high	true	no
overcast	hot	high	false	yes
rainy	mild	high	false	yes
rainy	cool	normal	false	yes
rainy	cool	normal	true	no
overcast	cool	normal	true	yes
sunny	mild	high	false	no
sunny	cool	normal	false	yes
rainy	mild	normal	false	yes
sunny	mild	normal	true	yes
overcast	mild	high	true	yes
overcast	hot	normal	false	yes
rainy	mild	high	true	no

attributes

examples

Example: symbolic weather data

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rainy	cool	normal	true	**no**
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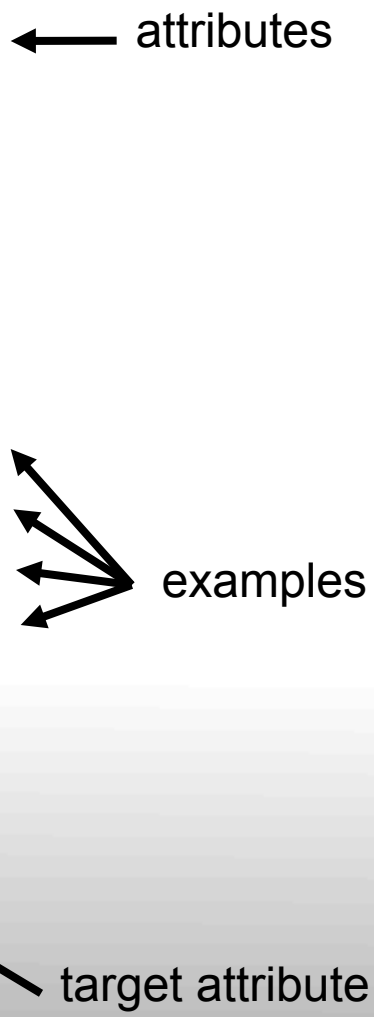
sunny	mild	high	false	**no**
sunny	cool	normal	false	**yes**
rainy	mild	normal	false	**yes**
sunny	mild	normal	true	**yes**
overcast	mild	high	true	**yes**
overcast	hot	normal	false	**yes**
rainy	mild	high	true	**no**



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rainy	cool	normal	true	**no**
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sunny	cool	normal	false	**yes**
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overcast	hot	normal	false	**yes**
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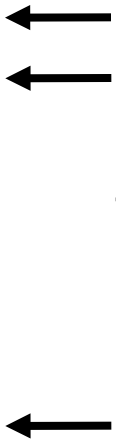

three examples covered,
100% correct

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Example: symbolic weather data

Outlook	Temperature	Humidity	Windy	Play
sunny	hot	**high**	false	**no**
sunny	hot	**high**	true	**no**
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rainy	mild	high	false	**yes**
rainy	cool	normal	false	**yes**
rainy	cool	normal	true	**no**
overcast	cool	normal	true	**yes**
sunny	mild	**high**	false	**no**
sunny	cool	normal	false	**yes**
rainy	mild	normal	false	**yes**
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three examples covered,
100% correct

if Outlook = sunny *and* Humidity = high *then* play = no

…

if Outlook = overcast *then* play = yes

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Example: symbolic weather data

Outlook	Temperature	Humidity	Windy	Play
sunny	hot	**high**	false	**no**
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three examples covered,
100% correct

if Outlook = sunny *and* Humidity = high *then* play = no

…

if Outlook = overcast *then* play = yes

…

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Numeric weather data

Outlook	Temperature	Humidity	Windy	Play
sunny	85	85	false	no
sunny	80	90	true	no
overcast	83	86	false	yes
rainy	70	96	false	yes
rainy	68	80	false	yes
rainy	65	70	true	no
overcast	64	65	true	yes
sunny	72	95	false	no
sunny	69	70	false	yes
rainy	75	80	false	yes
sunny	75	70	true	yes
overcast	72	90	true	yes
overcast	81	75	false	yes
rainy	71	91	true	no

numeric attributes

Numeric weather data

Outlook	Temperature	Humidity	Windy	Play
sunny	85 (hot)	85	false	no
sunny	80 (hot)	90	true	no
overcast	83 (hot)	86	false	yes
rainy	70	96	false	yes
rainy	68	80	false	yes
rainy	65	70	true	no
overcast	64	65	true	yes
sunny	72	95	false	no
sunny	69	70	false	yes
rainy	75	80	false	yes
sunny	75	70	true	yes
overcast	72	90	true	yes
overcast	81	75	false	yes
rainy	71	91	true	no

numeric attributes

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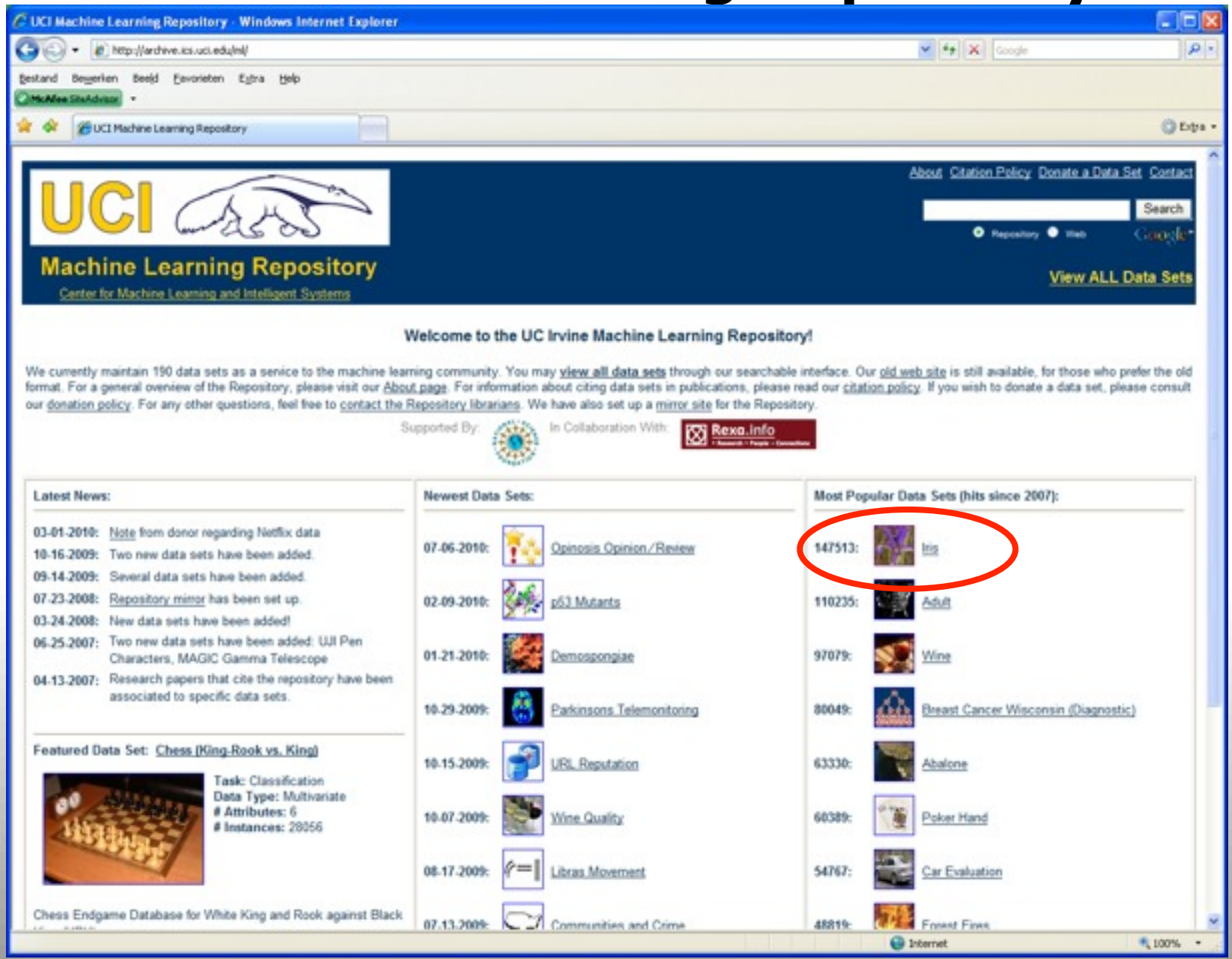
Numeric weather data

Outlook	Temperature	Humidity	Windy	Play
sunny	85	85	false	no
sunny	80	90	true	no
overcast	83	86	false	yes
rainy	70	96	false	yes
rainy	68	80	false	yes
rainy	65	70	true	no
overcast	64	65	true	yes
sunny	72	95	false	no
sunny	69	70	false	yes
rainy	75	80	false	yes
sunny	75	70	true	yes
overcast	72	90	true	yes
overcast	81	75	false	yes
rainy	71	91	true	no

if Outlook = sunny *and* Humidity > 83 *then* play = no

if Temperature < Humidity *then* play = no

UCI Machine Learning Repository



CPU performance data (regression)

MYCT	MMIN	MMAX	CACH	CHMIN	CHMAX	PRP	ERP
125	256	6000	256	16	128	198	199
29	8000	32000	32	8	32	269	253
29	8000	32000	32	8	32	220	253
26	8000	32000	64	8	32	318	290
23	16000	64000	64	16	32	636	749
23	32000	64000	128	32	64	1144	1238
400	1000	3000	0	1	2	38	23
400	512	3500	4	1	6	40	24
60	2000	8000	65	1	8	92	70
350	64	6	0	1	4	10	15
200	512	16000	0	4	32	35	64
…	…	…	…	…	…	…	…

MYCT: machine cycle time in nanoseconds
MMIN: minimum main memory in kilobytes
MMAX: maximum main memory in kilobytes
CACH: cache memory in kilobytes
CHMIN: minimum channels in units
CHMAX: maximum channels in units
PRP: published relative performance
ERP: estimated relative performance from the original article

numeric target attributes (Regression, numeric prediction)

CPU performance data (regression)

MYCT	MMIN	MMAX	CACH	CHMIN	CHMAX	PRP	ERP
125	256	6000	256	16	128	198	199
29	8000	32000	32	8	32	269	253
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26	8000	32000	64	8	32	318	290
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400	512	3500	4	1	6	40	24
60	2000	8000	65	1	8	92	70
350	64	6	0	1	4	10	15
200	512	16000	0	4	32	35	64
…	…	…	…	…	…	…	…

Linear model of Published Relative Performance:

PRP = -55.9 + 0.0489*MYCT + 0.0153*MMIN + 0.0056*MMAX +
0.641*CACH – 0.27*CHMIN + 1.48*CHMAX

Soybean disease data

- Michalski and Chilausky, 1980
- 'Learning by being told and learning from examples: an experimental comparison of the two methods of knowledge acquisition in the context of developing an expert system for soybean disease diagnosis.'
- 680 examples, 35 attributes, 19 categories
- Two methods:
  - rules induced from 300 selected examples
  - rules acquired from plant pathologist
- Scores:
  - induced model 97.5%
  - expert 72%

Soybean data

1. date: april,may,june,july,august,september,october,?.
2. plant-stand: normal,lt-normal,?.
3. precip: lt-norm,norm,gt-norm,?.
4. temp: lt-norm,norm,gt-norm,?.
5. hail: yes,no,?.
6. crop-hist: diff-lst-year,same-lst-yr,same-lst-two-yrs, same-lst-sev-yrs,?.
7. area-damaged: scattered,low-areas,upper-areas,whole-field,?.
8. severity: minor,pot-severe,severe,?.
9. seed-tmt: none,fungicide,other,?.
10. germination: 90-100%,80-89%,lt-80%,?.

…

32. seed-discolor: absent,present,?.
33. seed-size: norm,lt-norm,?.
34. shriveling: absent,present,?.
35. roots: norm,rotted,galls-cysts,?.

Soybean data

1. date: **april,may,june,july,august,september,october**,?.
2. plant-stand: normal,lt-normal,?.
3. precip: lt-norm,norm,gt-norm,?.
4. temp: lt-norm,norm,gt-norm,?.
5. hail: yes,no,?.
6. crop-hist: **diff-lst-year,same-lst-yr,same-lst-two-yrs, same-lst-sev-yrs**,?.
7. area-damaged: scattered,low-areas,upper-areas,whole-field,?.
8. severity: minor,pot-severe,severe,?.
9. seed-tmt: none,fungicide,other,?.
10. germination: **90-100%,80-89%,lt-80%**,?.

…

32. seed-discolor: absent,present,?.
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34. shriveling: absent,present,?.
35. roots: norm,rotted,galls-cysts,?.

Types

- Nominal, categorical, symbolic, discrete
  - only equality (=)
  - no distance measure
- Numeric
  - inequalities (<, >, <=, >=)
  - arithmetic
  - distance measure
- Ordinal
  - inequalities
  - no arithmetic or distance measure
- Binary
  - like nominal, but only two values, and True (1, yes, y) plays special role.

ARFF files

```
%
% ARFF file for weather data with some numeric features
%
@relation weather

@attribute outlook {sunny, overcast, rainy}
@attribute temperature numeric
@attribute humidity numeric
@attribute windy {true, false}
@attribute play? {yes, no}

@data
sunny, 85, 85, false, no
sunny, 80, 90, true, no
overcast, 83, 86, false, yes
...
```

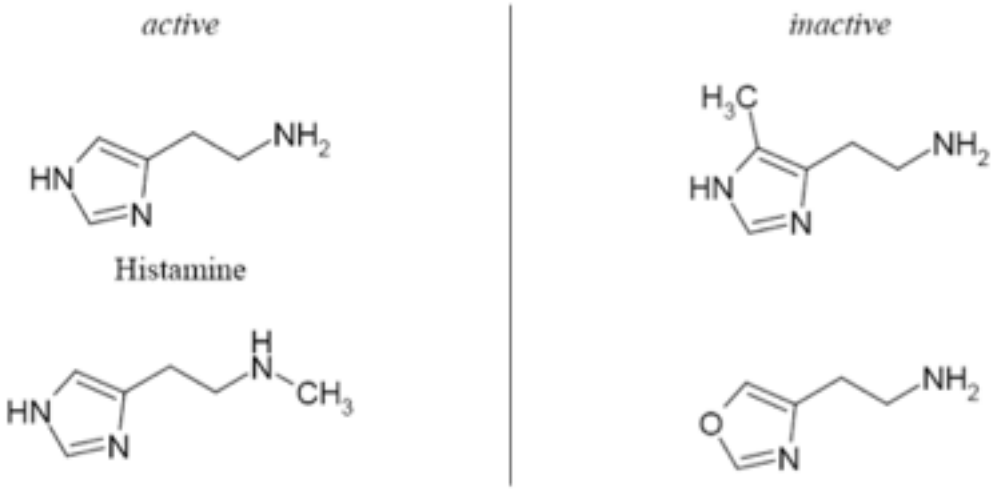
Other data representations

- time series
  - uni-variate
  - multi-variate

- Data streams
  - stream of discrete events, with time-stamp
  - e.g. shopping baskets, network traffic, webpage hits

Other representations

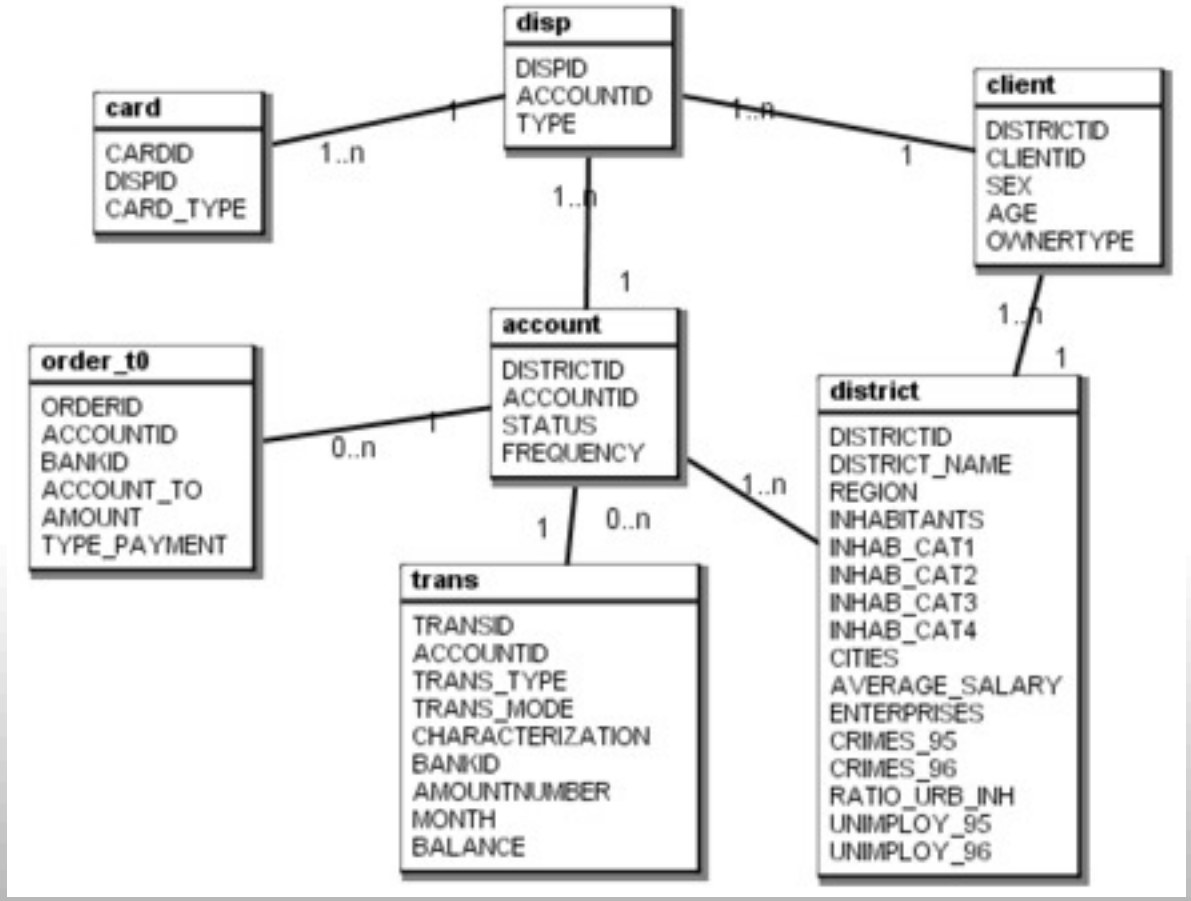
- Database of graphs



- Large graphs
  - social networks

Other representations

- Multi-relational data



Assignment

- Direct Marketing in holiday park
- Campaign for new offer uses data of previous booking:
  - customer id
  - price
  - number of guests
  - class of house
  - arrival date
  - departure date

  } data from previous booking

  - positive response? (target)
- Question: what alternative representations for the 2 dates can you suggest? The (multiple) new attributes should make explicit those features of a booking that are relevant (such as holidays etc).