Creative Data Mining

Uncover and evaluate



Lecture 4: Data Processing

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What we'll cover today

Data Processing

- A bit of theory & background
- Example: ESUM Project
- Start thinking about final project
- 2nd programming assignment





Background

How can data mining be creative?





What do we want to know?



Typical Knowledge Discovery Diagram (KDD)







How can data mining be creative?

Domain specific data source(s)





Typical Knowledge Discovery Diagram (KDD)



Background

The not-so creative, but essential part of data mining





Typical Knowledge Discovery Diagram (KDD)



Data Quality

"Garbage-in, garbage-out"



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Data Quality

What is dirty data?

Dirty data is.....

inaccurate, imprecise, unreliable, incomplete, inconsistent, irrelevant, invalid, ambiguous, redundant, or faked



Varun Ojha, (2015) A Computational Intelligence Perspective of Modelling and Data Analysis



Data Quality

- Accurate
- Precise
- Reliable
- Complete
- Consistent
- Relevant
- Sufficient (size)

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Major tasks in data preprocessing

Data cleaning

 Fill in missing values, smooth noisy data, identify or remove outliers, and resolve inconsistencies

Data integration

• Integration of multiple databases, data cubes, or files

Data transformation

Normalization and aggregation

Data reduction

 Obtains reduced representation in volume but produces the same or similar analytical results

Data discretization

 Part of data reduction but with particular importance, especially for numerical data

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https://www.mimuw.edu.pl/~son/datamining/DM/4-preproc

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Cleaning Tasks

- Data acquisition and metadata
- Fill in missing values
- Unified date format
- Converting nominal to numeric
- Identify outliers and smooth out noisy data
- Correct inconsistent data
- Convert data to a standard format (e.g. csv)

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Data Integration

- databases
- different databases



Look out for redundant data when integrating multiple

The same attribute may have different names in

One attribute may be a "derived" attribute from another

Careful integration of the data from multiple sources

Varun Ojha, (2015) A Computational Intelligence Perspective of Modelling and Data Analysis



Data transformation

- Smoothing: remove noise from data
- Aggregation: summarization, data cube construction
- Generalization: concept hierarchy climbing
- Normalization: scaled to fall within a small, specified range
- min-max normalization
- z-score normalization
- normalization by decimal scaling
- Attribute/feature construction
- New attributes constructed from the given ones

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Varun Ojha, (2015) A Computational Intelligence Perspective of Modelling and Data Analysis



Data reduction

- Feature Selection
- Selection.
- Feature Extraction
- E.g. Principle Component Analysis. Feature Analysis



Feature Reduction (Feature Selection or Feature Extraction)

E.g. Correlation-based feature selection, Stochastic feature

Varun Ojha, (2015) A Computational Intelligence Perspective of Modelling and Data Analysis







Example

ESUM- Analyzing trade-offs between Energy and Social performance of Urban Morphologies

Data from 37 participants in Zurich to:

Investigate impact of static (urban morphology) and dynamic features (environmental sensors) of the built environment on perception (using surveys and biofeedback data)







(a) Pathpoint 2, narrow



(c) Pathpoint 4, narrow



(e) Pathpoint 7, narrow



(g) Pathpoint 10, narrow



(d) Pathpoint 5, spaciou



(f) Pathpoint 8, spacious



(h) Pathpoint 11, spacious







Mobile sensor equipment

Sensorbackpack with environmental and position sensors



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Mobile Sensor equipment

Biofeedback wristband



PPG Sensor

Photoplethysmography Sensor - Measures Blood Volume Pulse (BVP), from which heart rate, heart rate variability (HRV), and other cardiovascular features may be derived



3-axis Accelerometer Captures motion-based

activity

signals

Event Mark Button Tags events and correlate them with physiological



E4 Sensors

EDA Sensor (GSR Sensor)

Electrodermal Activity Sensor - Used to measure sympathetic nervous system arousal and to derive features related to stress, engagement, and excitement.

Infrared Thermopile

Reads peripheral skin temperature

Internal Real-Time Clock

Temporal resolution up to 0.2 seconds in streaming mode

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https://www.empatica.com/e4-wristband



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Mobile Sensor equipment

Biofeedback wristband

Checkpoin Atmosphere	e ID:		
dislike		like	
chaotic noisy private boring crowded insecure ugly narrow enclosed dark		ordered quiet public interesting empty secure beautiful spacious open light	
Unfamiliar		Familiar	









Experimental data-set

ESUM- Analyzing trade-offs between Energy and Social performance of Urban Morphologies

Device	Sensor/ Measurement	units	Measurement range	Measurement frequency	Accuracy	Response tin
WaspCity	Sound Pressure	dB	50-100 dB	0.4 Hz	±2.5 dB	Not Given
					Resistive sensor 20MOhm (Darkness) 5-20	
	Luminosity	%	0-100% (400- 700 nm)	0.4 Hz	kOhm(Light)	Not Given
	Dust	mg/m3	Typical 0.5V/(0.1mg/m3)	0.4 Hz	Operating supply voltage 5±0.5V	10±1ms
WaspGas	Temperature	С	-40 ~ 125 C	0.25 Hz	±2 C(0-70 C), ±4 C(<0 C, >70C)	1.65 seconds
	Atmospheric Pressure	kPa	15 - 115 kPa	0.25 Hz	<±1.5% V	20 ms
	Humidity	%RH	0-100% RH	0.25 Hz	<±4% RH (a 25C, range 30-80%), ±6 %RH(range 0-100)	<15 seconds
Meshlium Scanner AP						
	Wifi Scanner	MAC address	Wifi Scanner (50-200m) Bluetooth Scanner (20-30m)	push values @ 0.016 Hz	Measurement range depends on he antenr and line of sight to the device	na 60 seconds
	Wifi Scanner	AP		push values @ 0.016 Hz		
	Wifi Scanner	RSSI (Received Signal Strenght Indicator)	-40 dBm (nearest node) to -90 dBm (marthes nodes)	push values @ 0.016 Hz	distance of 10m ~=(50dBm), 50m ~=(75dBm)	
Mobile Device				variable dependent on device satellit		
	GPS	Lat/Long	outdoor only	connection		
	Survey	12 questions, scale -2 to 2	NA	At checkpoint		
GPS	CDS	Lat/Long	outdoor only	1 山-7		
Biofeedback Wristband	GFS					
	PPG (Photoplethysmography)	Sensor output: Blood Volume Pulse (BPV)		64 Hz	0.9 nW/Digit	
	EDA (Electrodermal Activity)		0.01 mSiements -100 mSiemens	4 Hz		
	Skin Temperature Infrared	C	-40-115 C	Л Hz	+0.2 C within 36-39 C	
	3 Axis accelerometer			32 Hz		
		^, y, L		56116		

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Data Processing: ESUM Experiment

Data cleaning: unified date/time, convert WGS84 spherical coordinates to CH1903 planar coordinates



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1	1460644478	72.83	5.828598	0.000961	32.66	65.4761887	0.03806452	23.521	31.988	7036.3	(681400.69	247344.726
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4	1460644481	72.98	2.834946	0.001281	32.63	51.25	0.03935484	23.472	31.984	6547.5	(681400.736	247345.041
5	1460644482	73.05	3.309515	0.000961	32.66	51.25	0.03935484	23.448	31.982	6862.8	(681400.979	247344.748
6	1460644483	73.13	3.426358	0.001281	32.66	51.25	0.03935484	23.448	32.049	6799.7	(681401.131	247344.695
7	1460644484	73.23	4.381686	0.001281	32.65	64.8717957	0.03741935	23.448	32.116	6776.1	(681401.231	247344.77
8	1460644485	73.43	3.822565	0.001281	32.65	64.8717957	0.03741935	23.448	32.183	6918	(681401.305	247344.882
9	1460644486	73.7	7.809537	0.00064	32.65	63.9743576	0.04064516	23.448	32.183	7036.3	(681401.301	247345.142
10	1460644487	74	5.099897	0.00064	32.68	63.9743576	0.04064516	23.424	32.181	7059.9	(681401.324	247345.327
11	1460644488	74.3	5.686858	0.00064	32.66	63.9743576	0.04064516	23.4	32.179	7036.3	(681401.386	247345.402
12	1460644489	74.6	8.993654	0.001281	32.65	68.4523773	0.03935484	23.4	32.145	7288.5	(681401.357	247345.661
13	1460644490	74.87	4.041514	0.00032	32.65	68.4523773	0.03935484	23.4	32.179	7454.1	(681401.342	247345.809
14	1460644491	75.13	6.846003	0.000961	32.65	68.4523773	0.03935484	23.4	32.179	7351.6	(681401.444	247345.755
15	1460644492	75.35	12.109529	0.00064	32.66	60.1282043	0.04129032	23.376	32.176	7398.9	(681401.38	247345.847
16	1460644493	75.55	15.356786	0	32.63	60.1282043	0.04129032	23.376	32.176	6996.8	(681401.38	247345.828
17	1460644494	75.7	9.704498	0.000961	32.65	57.3684196	0.03870968	23.376	32.31	6981.1	(681401.405	247345.792
18	1460644495	75.92	28.555943	0.001281	32.65	57.3684196	0.03870968	23.352	32.509	6989	(681401.494	247345.737
19	1460644496	76.1	12.256844	0.001601	32.66	57.3684196	0.03870968	23.352	32.742	7004.7	(681401.582	247345.757
20	1460644497	76.28	71.173195	0.00032	32.66	63.3333321	0.04193548	23.352	32.909	6799.7	(681401.541	247345.997
21	1460644498	76.42	87.28521	0.00064	32.65	63.3333321	0.04193548	23.352	33.043	6989	(681401.5	247346.256
22	1460644499	76.55	25.758465	0.000961	32.65	63.3333321	0.04193548	23.328	33.041	7067.8	(681401.472	247346.46
23	1460644500	76.92	20.388626	0.000961	32.65	57.8947372	0.04129032	23.328	33.107	7067.8	(681401.418	247346.681
24	1460644501	77.32	15.548265	0.001281	32.66	57.8947372	0.04129032	23.304	33.239	6996.8	(681401.441	247346.886
25	1460644502	77.7	8.387268	0.00064	32.66	57.6315804	0.03935484	23.304	33.239	6941.7	(681401.398	247347.219
26	1460644503	78.08	9.249283	0.00064	32.66	57.6315804	0.03935484	23.304	33.239	6957.4	7	681401.369	247347.533
27	1460644504	78.45	14.46798	0.001281	32.63	57.6315804	0.03935484	23.304	33.372	6933.8	7	681401.392	247347.7
28	1460644505	78.82	19.762161	0.00032	32.63	58.9473686	0.04	23.112	33.488	6910.1	7	681401.389	247347.941
29	1460644506	79.15	26.95731	0.002242	32.65	58.9473686	0.04	23.088	33.619	6925.9		681401.205	247348.458

D. Griego, V. Buff, E. Hayos, I. Moise, E. Pournaras (2017), Sensing and mining urban qualities in smart cities, proceedings in AINA IEEE 31st Conference



Data Processing: ESUM Experiment

Data integration and reduction: frequency reduction and and integration from multiple data sources

Sensor description	Frequency [Hz]
Heart rate (HR)	1
Blood volume pressure (BVP)	64
Electrodermal activity (EDA)	4
Biofeedback temperature (T-BF)	1
Sound level (S)	0.3
Dust (D)	0.3
Environment temperature (T-EN)	1
Relative humidity (RH)	1
Illuminance (IL)	1
People density (PD)	1 (if many), 0.024 (if few)
Longitude (LON)	1
Latitude (LAT)	1
Survey answers	In each of the 14 checkpoints

TABLE III. DATA COLLECTION FREQUENCIES.





Fig. 4. Frequency reduction applied to the bloom volume pressure measurements.

D. Griego, V. Buff, E. Hayos, I. Moise, E. Pournaras (2017), Sensing and mining urban qualities in smart cities, proceedings in AINA IEEE 31st Conference



Data processing: ESUM Experiment



Fig. 5.



D. Griego, V. Buff, E. Hayos, I. Moise, E. Pournaras (2017), Sensing and mining urban qualities in smart cities, proceedings in AINA IEEE 31st Conference



Data processing: ESUM Experiment

Data integration and reduction: Geo-referencing data to specific locations



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Data processing: ESUM Experiment

Data reduction: feature extraction

Checkpoint ID: Atmosphere						
dislike		like				
chaotic noisy private boring crowded insecure ugly narrow enclosed dark		ordered quiet public interesting empty secure beautiful spacious open light				
Unfamiliar		Familiar				





TABLE I. QUESTIONS AND RANGES OF RATINGS FROM WHICH CITIZENS MAKE SELECTIONS. THE VIRTUAL SENSOR USING EACH QUESTIONS IS INDICATED.

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	1
esting Boring Light - Dark	
ACT ACT	
10 11	
uiet Noisy Secure - Insecure	S
EXP EXP	
n	sting BoringLight - DarkACTACT1011niet NoisySecure - InsecureEXPEXP





Course Schedule

Start thinking about your final projects

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Mondays 10:00 - 12:00 051-0726-17U|2ECTS*

Creative Data Mining Uncover and Evaluate

The participants of this course learn how to collect, process, analyze and interpret real spatial and temporal data in order to work with quantifiable qualities in urban planning. This is achieved by using actual data from a recent study and analysing it with different data processing and machine learning techniques.

The goal of the course is to explore a specific research question about the urban environment and test the stated hypothesis using different techniques presented in the course, thus preparing students with a skill-set to further support their design and decision making processes.

The course focuses on creating deeper insights to critically evaluate design alternatives for urban planning projects. Students will work with time-series and geo-referenced data including temperature, relative humidity, illuminance, noise, people density, and dust particulate matter. Subjective impression survey data will also be integrated into the student projects to further explore influencing factors of the urban environment on our perceptual experiences. Non-architectural skills the participants can develop during this course are 1) an introduction to programming 2) how clustering methods like PCA or K-Means could be applied in an architectural context.

Where HIT H 34.1 (Video Wall)

Supervision

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Prof. Dr. Gerhard Schmitt Chair of Information Architecture Information Science Lab Wolfgang-Pauli-Strasse 27, 8093 Zurich www.ia.arch.ethz.ch

20.02.2017	Course Introduction
27.02.2017	Introduction to Python & Programming I
06.03.2017	Introduction to Python & Programming II
13.03.2017	Data Processing
20.03.2017	Seminar week (No lecture)
27.03.2017	Intro to time-series data analysis
03.04.2017	Time series data analysis ctd. & Machine le
10.04.2017	Machine learning ctd.
17.04.2017	Holiday (No lecture)
24.04.2017	Programming tutorial applications
01.05.2017	Holiday (No lecture)
08.05.2017	Q&A Feedback Workshop I
15.05.2017	Final iA critique Combined critique with the other iA courses (13:00 - 18:00)

Requirement Former knowledge of any digital tool or coding language is most welcome but NOT required. You only need to provide a reasonable amount of motivation and of course a notebook.

* Total 60 h = 2 ECTS Ungraded Semester Performance

The most recent outline will be found on www.ia.arch.ethz.ch









Semester Project

- Formulate 1-2 specific question(s) of interest to you 1.
- State your hypothesis/expected outcome based on supporting 2. literature (minimum one source) your expertise, and intuition
- Answer that question through your analysis, for this: З.
 - Select the best available data sources for your question (min. of 2 data sources)
 - Include a time series and/or clustering analysis
- Summarize your results 4.
- Conclusions & lessons learned 5.
- Include motivation and references 6.

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Show a clear conclusion, does your analysis answer your question(s)?



2nd Conceptual Homework

Project Ideas

For next class:

- 1. your final project
 - ۲ to know (research question)
 - Come up with questions for us, have fun and be creative •



Prepare 1-3 slides to describe what you would like to do for

This includes a specific hypothesis, possible data sources, and what you'd like

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2nd Programming assignment

Data Processing: data transformation

Transform survey response data from each ESUM participant by survey question:

 \rightarrow (12 questions, 14 check points) per participant to a single matrix for each question (32 participants, 14 check points)

→Headers from participant data files: ["Date-Time", "path-point", "like-dislike", "familiar-unfamiliar", "ordered-chaotic", "quiet-noisy", "public-private", "interesting-boring", "empty-crowded", "secureinsecure", "beautiful-ugly", "spacious-narrow", "openenclosed", "light-dark"]

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Questions?



Lecture 4: Data Processing

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Another example

Interactive data visualization from Boston metro



Entrances and Exits per Station during February 2014

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Size shows turnstile entries on average day

Each circle above and row in the table represent a station, hover over one to highlight the other. Next to each station are heatmaps showing entrances and exits to each station per-hour for weekdays and weekends/holidays.

Notice work stations with exit peaks in the morning and entrances peak in the afternoon, home stations with entrance peaks in the morning and exit peaks in the afternoon, and the stations that are just busy all the time.

Larvard Let: Ubit für Let: Ubit für South Station 11 South Station 13,800 Park Street 13,800 South Station 13,800 Central Square 13,800 Back Bay 13,800 Scredal Square 11,200 Control Square 11,200 State Street 9,800 Valid Conter 9,800 Halden Center 9,100 Haymarket 8,900 Valid Square 9,100 Haymarket 8,900 Valid Square 8,900 Valid Mass Square 5,500 </th <th>Station</th> <th>Avg. Weekday</th> <th>Avg. Weekend</th> <th>Avg. Turnstile Entries per day</th> <th></th>	Station	Avg. Weekday	Avg. Weekend	Avg. Turnstile Entries per day	
arvardo 11 Downtown Crossing 16,900 Park Street 13,600 Contral Square 13,600 Bark Baret 13,600 Contral Square 13,600 Dark Street 13,600 Contral Square 12,800 Davis Square 9,100 State Street 9,400 Malden Center 9,400 Haymarket 8,900 Charles MGH 8,900 Ruggles 8,300 Sovernment Center 8,200 Sovernment Center 7,700 Order Square 7,700 Order Square 7,700 Order Square 7,700 Order Square 5,500 Alirport 5,500 Astreet 5,500 Vellington 5,500 Charles Maret 3,600 Alirport 5,500 Alirport 5,500 Alirport 5,500 Charles Maret 3,600 Alirport 5,600 Charles Maret 5,200	Line and	6am 12pm 6pm	6am 12pm 6pm		10.400
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Ownitown Crossing 15,900 Park Street 13,800 Stark Bay 13,800 Back Bay 13,800 Sark Bay 13,800 Sark Bay 12,800 Contral Square 11,200 Torest Hills 11,200 Davis Square 9,800 State Street 9,800 Malden Center 9,100 Haymarket 8,900 Charles MGH 8,900 State Street 8,900 Government Center 8,200 Ocker Square 8,200 Government Center 8,200 Order Square 6,500 UrKU Mass 7,400 Urkorth Government Center 6,500 Outer Square 5,400 Velligton 5,500 Charles KGrave 5,300 Urk Medical Center 5,100 North Cullocy 5,100 Order Square 4,800 Order Square 4,800 Order Square 4,200 <t< td=""><td>South Station</td><td></td><td></td><td></td><td>19,100</td></t<>	South Station				19,100
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Haymarket 8,900 Ruggles 8,800 Maverick 8,400 Sullivan Square 8,300 Alewife 8,200 Oversick 8,200 Sullivan Square 8,200 Alewife 8,200 Porter Square 7,700 Porter Square 7,700 Porter Square 6,500 Almont 6,500 Quincy Center 6,500 Mass Ave 5,500 Vallington 5,500 Chinatown 5,400 Mass Ave 5,300 Tufts Medical Center 5,100 North Quincy 4,900 Andrew Square 4,900 Wonderland 4,800 Jackson Square 4,200 Fields Corner 4,100 Robury Crossing 3,700 Braintree 3,600 Aquarium 3,600 Wolleston 2,800 Oriert Heights 2,800 Green Street 2,800 Beachmont 2,400 Beachmot	Malden Center			9,100	
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Shawmut 1,700 Wood Island 1,500 Bowdoin 1,300 Suffolk Downs 500	Savin Hill			1,900	
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Suffolk Downs 500	Bowdoin			1,300	
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