Week 5: Action Rules

CS286: Topics in Intelligent Systems

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Agenda

1. Introduction
   - Readings
   - Example
2. Case study
   - Business decision making
   - Medical decision making
3. Algorithms
   - Mining algorithms
   - Activity

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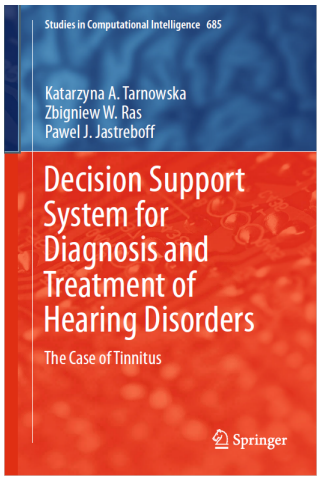
Required readings

1. **Chapter 4.4: Action Rules** in Decision Support System for Diagnosis and Treatment of Hearing Disorders. The Case of Tinnitus.
   OR
2. **Chapter 4.1.3: Action rules** in Recommender System for Improving Customer Loyalty.



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Action rules - introduction

An action rule /Ras & Wieczorkowska, PKDD 2000/ is a rule extracted from an information system that *describes a possible transition of objects from one state to another* with respect to a distinguished attribute called a decision attribute

Information System

	A	B	D
	a1	b2	d1
	a2	b2	
	a2	b2	d2

Assumption:

- attributes are partitioned into stable and flexible

Values of attributes can be changed

Action rules - introduction

Action rule is defined as a term $[(\omega) \wedge (\alpha \rightarrow \beta)] \rightarrow (\phi \rightarrow \psi)$

conjunction of fixed condition features shared by both groups

proposed changes in values of flexible features

desired effect of the action

Information System

	A	B	D
	a1	b2	d1
	a2	b2	
	a2	b2	d2

Action rules - example

X	a	b	c	d
x_1	0	S	0	L
x_2	0	R	1	L
x_3	0	S	1	L
x_4	0	R	1	L
x_5	2	P	2	L
x_6	2	P	2	L
x_7	2	S	2	H

Decision Table

{a, c} - stable attributes,
{b, d} - flexible attributes,
d - decision attribute.

Rules discovered:

$r_1 = [(b, P) \rightarrow (d, L)]$

$r_2 = [(a, 2) \wedge (b, S) \rightarrow (d, H)]$

Action rule:

$[(a, 2) \wedge (b, P \rightarrow S)](x) \Rightarrow [(d, L \rightarrow H)](x)$

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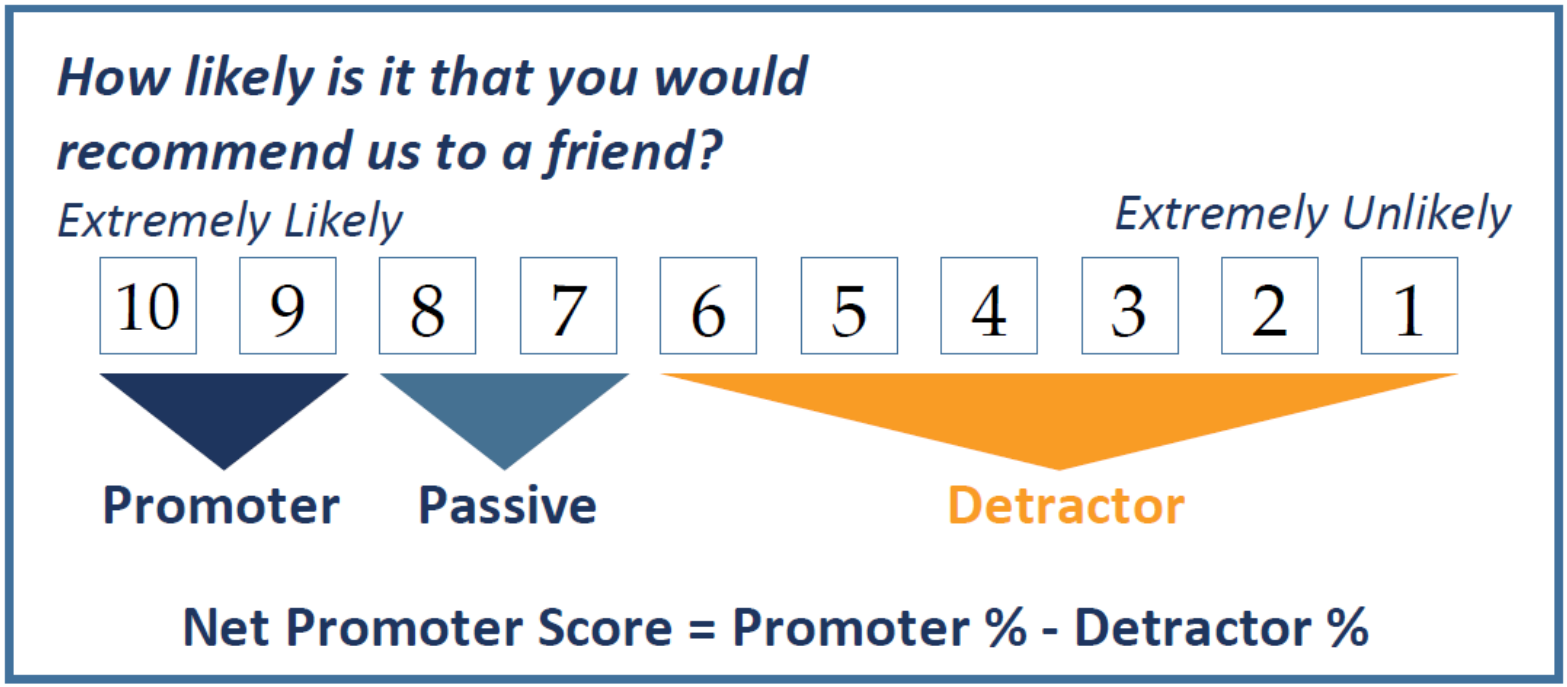
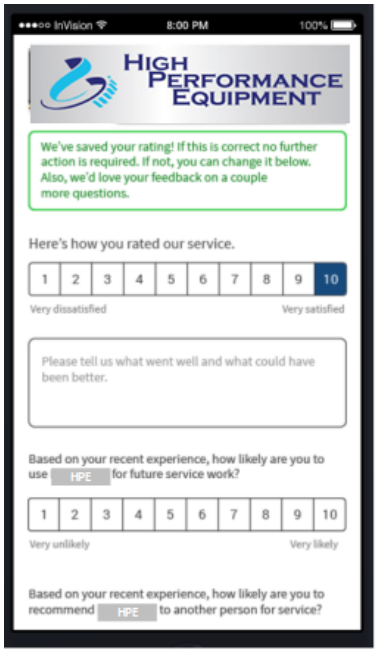
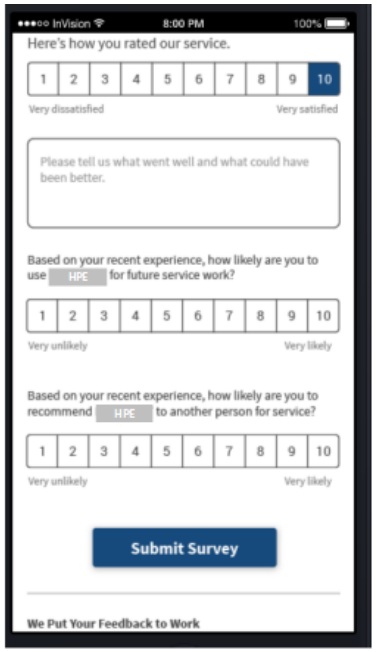
Decision Problem: How to change the customer from Detractor to Promoter?



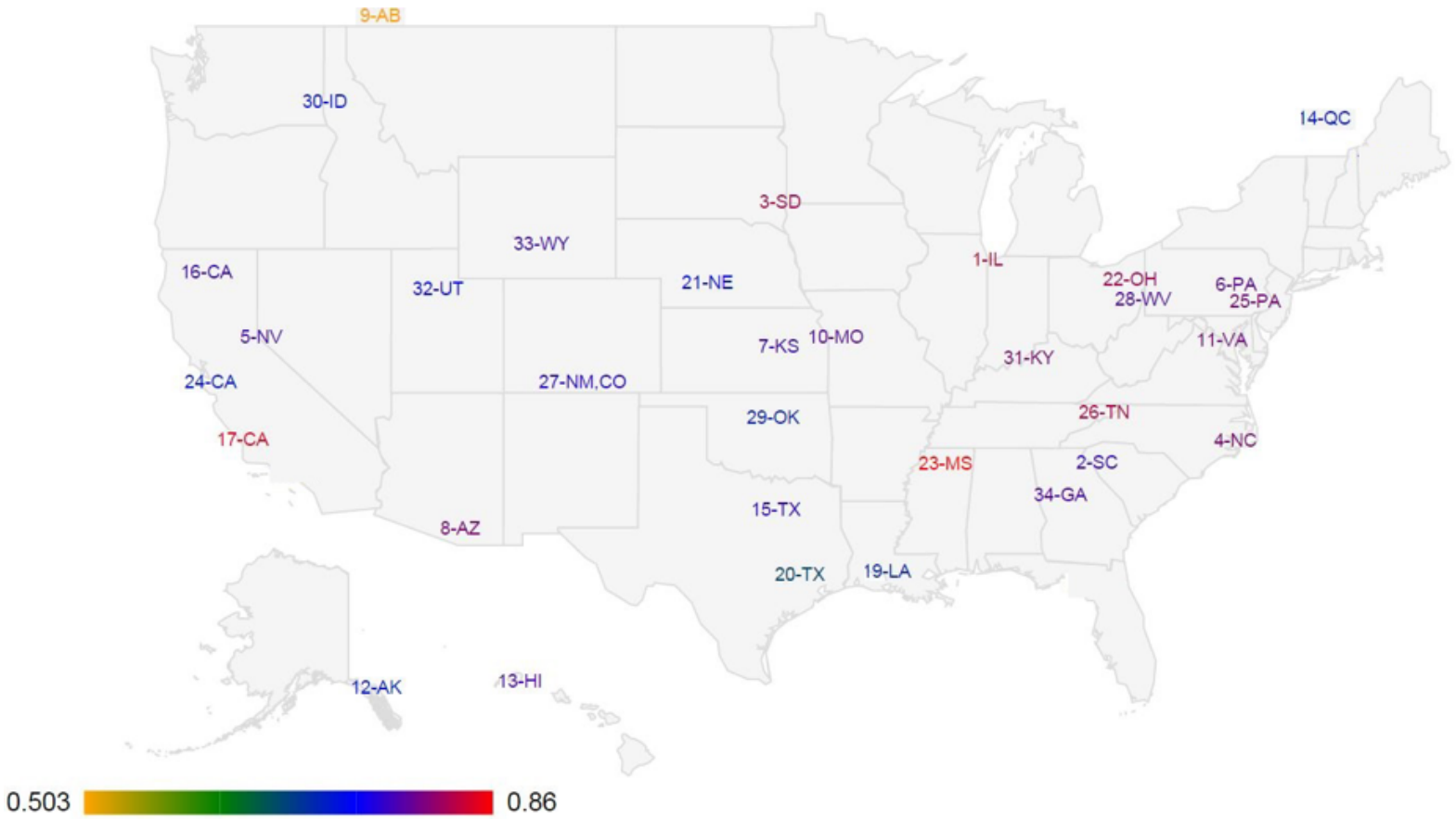
Case study - data collection

- Survey questions ("benchmarks") scored 1-10
- Each asks about customer experience in a particular area





NPS rating for all clients



Large datasets of customer feedback surveys

- **Stable attributes**: client, division, survey type
- **Flexible attributes**: scores for the benchmark questions
- **Decision**: net promoter score (NPS) status

Client attributes			Customer attributes			Service attributes		Survey attributes and questions (customer experience on client's service)				NPS Status
ID	Name	Adress, ...	Name	Location	...	Time	Cost ,...	Q1 (score)	Q2 (score)	Q... (score)	QN (score)	Promoter
1												Passive
2												Detractor

- **Analytical problem**: How to change the customer from Detractor to Promoter?

Action rule mining

- Patterns mined from large datasets
- Descriptive models for actionable knowledge
- Each rule is characterized by:
  - Support - the number of objects matching the rule "before" state (here, how many customers can be changed)
  - Confidence - "probability" of the change to occur (here, the probability of changing a customer)

Example

IF Benchmark1 (3->6) AND Benchmark2 (7->9)

THEN Detractor -> Promoter, sup=10, conf=90%

10 customers can be changed in this way with the probability of 90%

Application of action rules for business decision-making

Action rule

Shows actions to undertake

IF Benchmark1 (3->6) AND Benchmark2 (7->9)

THEN Detractor -> Promoter

To make change happen

„Traditional" rules:

IF Benchmark1 =3 AND Benchmark2 =7

THEN Detractor

IF Benchmark1 =6 AND Benchmark2 =9

THEN Promoter

Show simply associations

Case study - complete reference

- Chapter 5.5: Action Rules

Agenda

Tinnitus retraining therapy (TRT) protocol

Sound Therapy

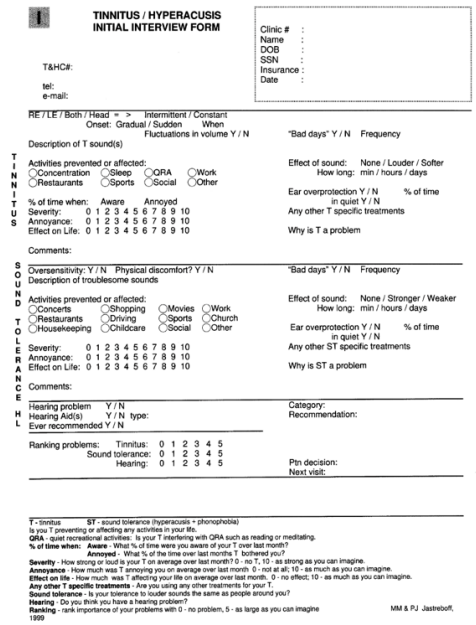
- Sound stimulation provided to the auditory system aims at decreasing tinnitus signal
- Sound generator devices must be fitted

Counseling

- Aims at reclassifying tinnitus to neutral stimuli ("retrain" conditioned reflexes)
- Delivered as individual therapy

Data collection

Structured interview (questionnaires) + audiological assessment



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TINNITUS / HYPERACUSIS INITIAL INTERVIEW FORM

Clinic # :
Name :
DOB :
SSN :
Insurance :
Date :

T&HC#:

tel:
e-mail:

RE / LE / Both / Head = > Intermittent / Constant
Onset: Gradual / Sudden When
Fluctuations in volume Y / N

Description of T sound(s)

"Bad days" Y / N Frequency

TINNITUS

Activities prevented or affected:
◯Concentration ◯Sleep ◯QRA ◯Work
◯Restaurants ◯Sports ◯Social ◯Other

Effect of sound: None / Louder / Softer
How long: min / hours / days

% of time when: Aware Annoyed
Severity: 0 1 2 3 4 5 6 7 8 9 10
Annoyance: 0 1 2 3 4 5 6 7 8 9 10
Effect on Life: 0 1 2 3 4 5 6 7 8 9 10

Ear overprotection Y / N % of time in quiet Y / N

Any other T specific treatments

Why is T a problem

Comments:

SOUND TOLERANCE

Oversensitivity: Y / N Physical discomfort? Y / N
Description of troublesome sounds

"Bad days" Y / N Frequency

Activities prevented or affected:
◯Concerts ◯Shopping ◯Movies ◯Work
◯Restaurants ◯Driving ◯Sports ◯Church
◯Housekeeping ◯Childcare ◯Social ◯Other

Effect of sound: None / Stronger / Weaker
How long: min / hours / days

Ear overprotection Y / N % of time in quiet Y / N

Severity: 0 1 2 3 4 5 6 7 8 9 10
Annoyance: 0 1 2 3 4 5 6 7 8 9 10
Effect on Life: 0 1 2 3 4 5 6 7 8 9 10

Any other ST specific treatments

Why is ST a problem

Comments:

HEARING

Hearing problem Y / N
Hearing Aid(s) Y / N type:
Ever recommended Y / N

Category:
Recommendation:

Ranking problems: Tinnitus: 0 1 2 3 4 5
Sound tolerance: 0 1 2 3 4 5
Hearing: 0 1 2 3 4 5

Ptn decision:
Next visit:

T - tinnitus ST - sound tolerance (hyperacusis + phonophobia)
Is you T preventing or affecting any activities in your life.
QRA - quiet recreational activities: Is your T interfering with QRA such as reading or meditating.
% of time when: **Aware** - What % of time were you aware of your T over last month?
Annoyed - What % of the time over last months T bothered you?
Severity - How strong or loud is your T on average over last month? 0 - no T, 10 - as strong as you can imagine.
Annoyance - How much was T annoying you on average over last month 0 - not at all; 10 - as much as you can imagine.
Effect on life - How much was T affecting your life on average over last month. 0 - no effect; 10 - as much as you can imagine.
Any other T specific treatments - Are you using any other treatments for your T.
Sound tolerance - Is your tolerance to louder sounds the same as people around you?
Hearing - Do you think you have a hearing problem?
Ranking - rank importance of your problems with 0 - no problem, 5 - as large as you can imagine
MM & PJ Jastreboff, 1999

FU

TINNITUS / HYPERACUSIS FOLLOW-UP INTERVIEW FORM

CATEGORY:
Date of Init. couns.
Date of instr. fit.
SG:
HA:
FUQ #:
Month #:

Clinic # :
Name :
DOB :
SSN :
Insurance :
Date :

T&HC#:

tel:

"Bad days" Y / N Frequency
Are they: as frequent Y / N as bad Y / N

Activities prevented or affected: Changes: Y / N
◯◯Concentration ◯◯Sleep ◯◯QRA ◯◯Work

Effect of sound: None / Louder / Softer

Is you T preventing or affecting any activities in your life. ●◯ - an activity affected at first visit
QRA - quiet recreational activities: Is your T interfering with QRA such as reading or meditating. ◯● - an activity affected as for today
% of time when: **Aware** - What % of time were you aware of your T over last month?
Annoyed - What % of the time over last months T bothered you?
Severity - How strong or loud is your T on average over last month? 0 - no T, 10 - as strong as you can imagine.
Annoyance - How much was T annoying you on average over last month 0 - not at all; 10 - as much as you can imagine.
Effect on life - How much was T affecting your life on average over last month. 0 - no effect; 10 - as much as you can imagine.
Any other T specific treatments - Are you using any other treatments for your T.
Sound tolerance - Is your tolerance to louder sounds the same as people around you?
Hearing - Do you think you have a hearing problem?
Ranking - rank importance of your problems with 0 - no problem, 5 - as large as you can imagine
MM & PJ Jastreboff, 1999

Tinnitus Handicap Inventory (THI)

This form is for informational purposes only and should not take the place of consultation and evaluation by a healthcare professional.

Your Name: Date:

Instructions: The purpose of this questionnaire is to identify, quantify, and evaluate the difficulties that you may be experiencing because of tinnitus. Please do not skip any questions. When you have answer all the questions, add up your total score, based on the values for each response.

1.	Because of your tinnitus, is it difficult for you to concentrate?	○ Yes (4) ○ Sometimes (2)	○ No (0)
2.	Does the loudness of your tinnitus make it difficult for you to hear people?	○ Yes (4) ○ Sometimes (2)	○ No (0)
3.	Does your tinnitus make you angry?	○ Yes (4) ○ Sometimes (2)	○ No (0)
4.	Does your tinnitus make you feel confused?	○ Yes (4) ○ Sometimes (2)	○ No (0)
5.	Because of your tinnitus, do you feel desperate?	○ Yes (4) ○ Sometimes (2)	○ No (0)
6.	Do you complain a great deal about your tinnitus?	○ Yes (4) ○ Sometimes (2)	○ No (0)
7.	Because of your tinnitus, do you have trouble falling to sleep at night?	○ Yes (4) ○ Sometimes (2)	○ No (0)
8.	Do you feel as though you cannot escape your tinnitus?	○ Yes (4) ○ Sometimes (2)	○ No (0)
9.	Does your tinnitus interfere with your ability to enjoy your social activities (such as going out to dinner, to the movies)?	○ Yes (4) ○ Sometimes (2)	○ No (0)
10.	Because of your tinnitus, do you feel frustrated?	○ Yes (4) ○ Sometimes (2)	○ No (0)
11.	Because of your tinnitus, do you feel that you have a terrible disease?	○ Yes (4) ○ Sometimes (2)	○ No (0)
12.	Does your tinnitus make it difficult for you to enjoy life?	○ Yes (4) ○ Sometimes (2)	○ No (0)
13.	Does your tinnitus interfere with your job or household responsibilities?	○ Yes (4) ○ Sometimes (2)	○ No (0)
14.	Because of your tinnitus, do you find that you are often irritable?	○ Yes (4) ○ Sometimes (2)	○ No (0)
15.	Because of your tinnitus, is it difficult for you to read?	○ Yes (4) ○ Sometimes (2)	○ No (0)
16.	Does your tinnitus make you upset?	○ Yes (4) ○ Sometimes (2)	○ No (0)
17.	Do you feel that your tinnitus problem has placed stress on your relationships with members of your family and friends?	○ Yes (4) ○ Sometimes (2)	○ No (0)
18.	Do you find it difficult to focus your attention away from your tinnitus and on other things?	○ Yes (4) ○ Sometimes (2)	○ No (0)
19.	Do you feel that you have no control over your tinnitus?	○ Yes (4) ○ Sometimes (2)	○ No (0)
20.	Because of your tinnitus, do you often feel tired?	○ Yes (4) ○ Sometimes (2)	○ No (0)
21.	Because of your tinnitus, do you feel depressed?	○ Yes (4) ○ Sometimes (2)	○ No (0)
22.	Does your tinnitus make you feel anxious?	○ Yes (4) ○ Sometimes (2)	○ No (0)
23.	Do you feel that you can no longer cope with your tinnitus?	○ Yes (4) ○ Sometimes (2)	○ No (0)
24.	Does your tinnitus get worse when you are under stress?	○ Yes (4) ○ Sometimes (2)	○ No (0)
25.	Does your tinnitus make you feel insecure?	○ Yes (4) ○ Sometimes (2)	○ No (0)

The sum of all responses is your THI Score >>> 0

0-16: Slight or no handicap (Grade 1)
18-36: Mild handicap (Grade 2)
38-56: Moderate handicap (Grade 3)
58-76: Severe handicap (Grade 4)
78-100: Catastrophic handicap (Grade 5)

Newman CW, Jacobson GP, Spitzer JB. (1996) "Development of the Tinnitus Handicap Inventory." Archives of Otolaryngology - Head and Neck Surgery. 122(2):143-8.
McCombe, A., Baguley, D., Coles, R., McKenna, L., McKinney, C. & Windle-Taylor, P. (2001). "Guidelines for the Grading of Tinnitus Severity: the Results of a Working Group Commissioned by the British Association of Otolaryngologists, Head and Neck Surgeons." Clinical Otolaryngology, 26, 388-393.

Decision table

- **Objects**: patient visits (follow-up)
- **Stable attributes**: patient's demographics, medical profile, etiology, etc.
- **Flexible attributes**: instrument model, follow-up type, etc.
- **Decision**: tinnitus handicap inventory (THI) score

V#	Date	Patient profile					Follow-up Interview			Treatment		REM	THI
		Age	Gender	Etiology	Category	...	Tinnitus	Decreased Sound Tolerance	Hearing Loss	Sound Therapy	Counseling		
1													
2													

Action rules: sound therapy changes that descrease THI

V#	Patient profile					Follow-up Interview	Treatment		REM	THI
	Age	Gender	Etiology	Category	...	Tinnitus	Sound Therapy	Counseling		
1		M	NTI				GHH			90
1		M	NTI				GHS			70

Stable attributes **Flexible attributes** **Decision** **Confidence**

G(m) & NTI(yes): (Inst_vis(01)(GHH →GHS)) ⟹ THI(90 →70), Conf. = 80%

Interpretation: *If* a patient is a male and tinnitus is noise-induced, *then* changing sound therapy from the instrument model of GH hard to GH soft at the first visit improves a patient, with 80% confidence.

Action rules: REM changes that descrease THI

V#	Patient profile					Follow-up Interview	Treatment		REM	THI
	Age	Gender	Etiology	Category	...	Tinnitus	Sound Therapy	Counseling	Mix R SL	
1							SG		11	90
1							SG		9	70

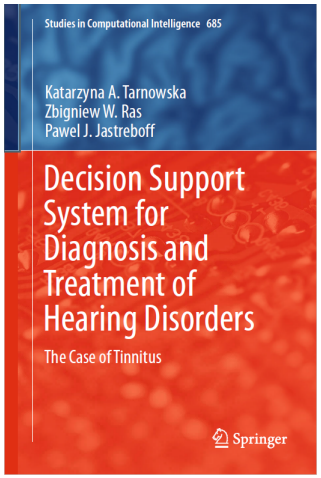
Stable | **Flexible attributes** | **Decision** | **Confidence**

Ins(SG): (Mix_R_SL(<11;12) → (<9;10))⟹ THI(90 →70), Conf. = 100%

Interpretation: *If* treatment involved sound generator, *then* changing the setting to the mixing point for the right ear from <11;12) to <9;10) will improve a patient's state with 100% confidence.

Case study - complete reference

- Chapter 8: Experiment 3: Treatment Rules
- Chapter 9: Experiment 4: Treatment Rules Enhancement



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Methods for action rule extraction

- Rule-based
  - Prior extraction of classification rules is needed
  - Example - DEAR /Tsay & Ras, tree-based strategy
  - Ąction rules discovery: System DEAR2, method and experiments", L.-S. Tsay, Z.W. Ras, Journal of Experimental and Theoretical Artificial Intelligence, Taylor Francis, Vol. 17, No. 1-2, 2005, 119-128
- Object-based
  - Action rules are extracted directly from DB
  - Example – ARED /similar to Apriori/
  - Ąssociation Action Rules", Z.W. Ras, A. Dardzinska, L.-S. Tsay, H. Wasyluk, IEEE/ICDM Workshop on Mining Complex Data (MCD 2008), Pisa, Italy, ICDM Workshops Proceedings, IEEE Computer Society, 2008, 283-290

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Graded Lab

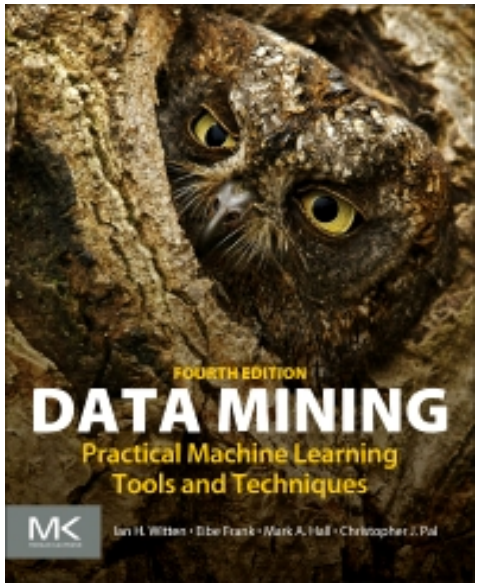
Lab 4 activity: predictive modeling

Working with the dataset you chose in Lab 1-3 and complete the following tasks:

- Choose at least three classification algorithms to build predictive models for your decision attributes.
- Perform evaluation of the built predictive models using cross-validation method.

Lab 4 - reference

- Chapter 3: Output: knowledge representation
- Chapter 4: Algorithms: the basic methods
- Chapter 9: Probabilistic methods
- Chapter 10: Deep learning



Self-check

Try to answer the following questions:

1. What is the *action rule*?
2. What are the *stable* and *flexible* attributes?
3. Give an example of action rules, describe the stable and flexible attributes.
4. List and describe methods for action rule extraction.