



資料探勘： 從關聯規則分析到子群組探勘

KNOWLEDGE-BASED ANNOTATION LEARNING SYSTEM

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Actionable Rule

Subgroup Discovery

能夠付諸行動的規則：子群組探勘



吃藥吃出人命啦！

藥商快想想辦法啊！

敘述統計

吃了你藥的病患中，
有10個人
都病得更重了！

子群組探勘

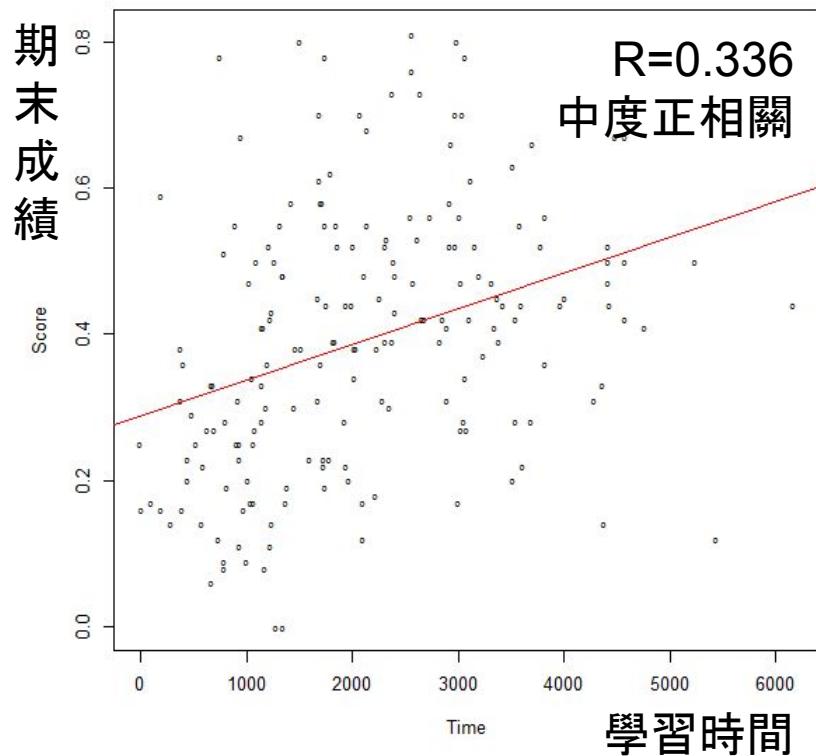
吃了你藥的病患中，
有吸菸的大多數病患們
都病得更重了！

找出隱含在整體資料的潛在規則

子群組探勘

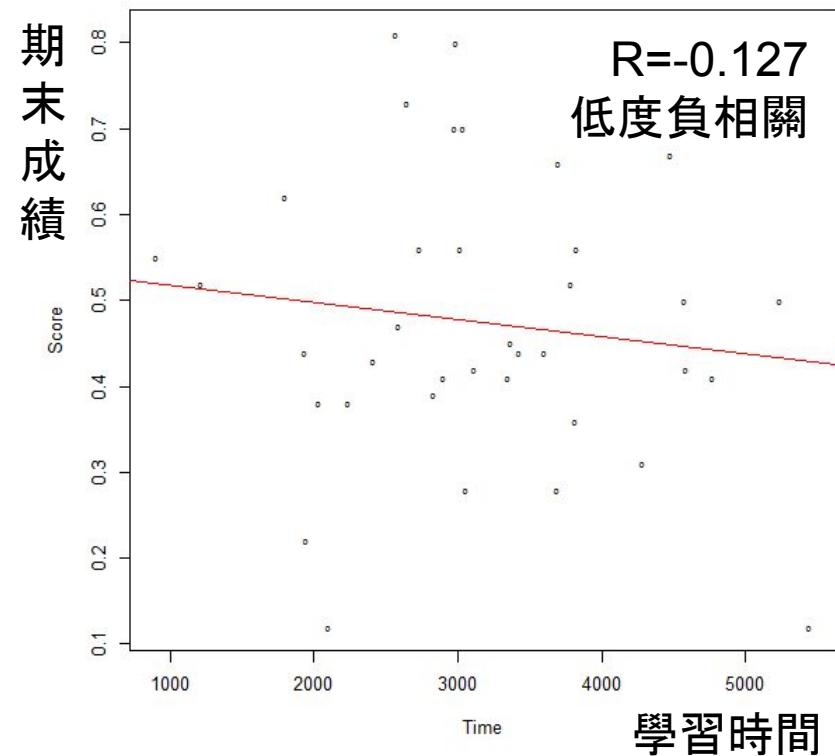
整體狀況

學習時間越長，期末成績越好

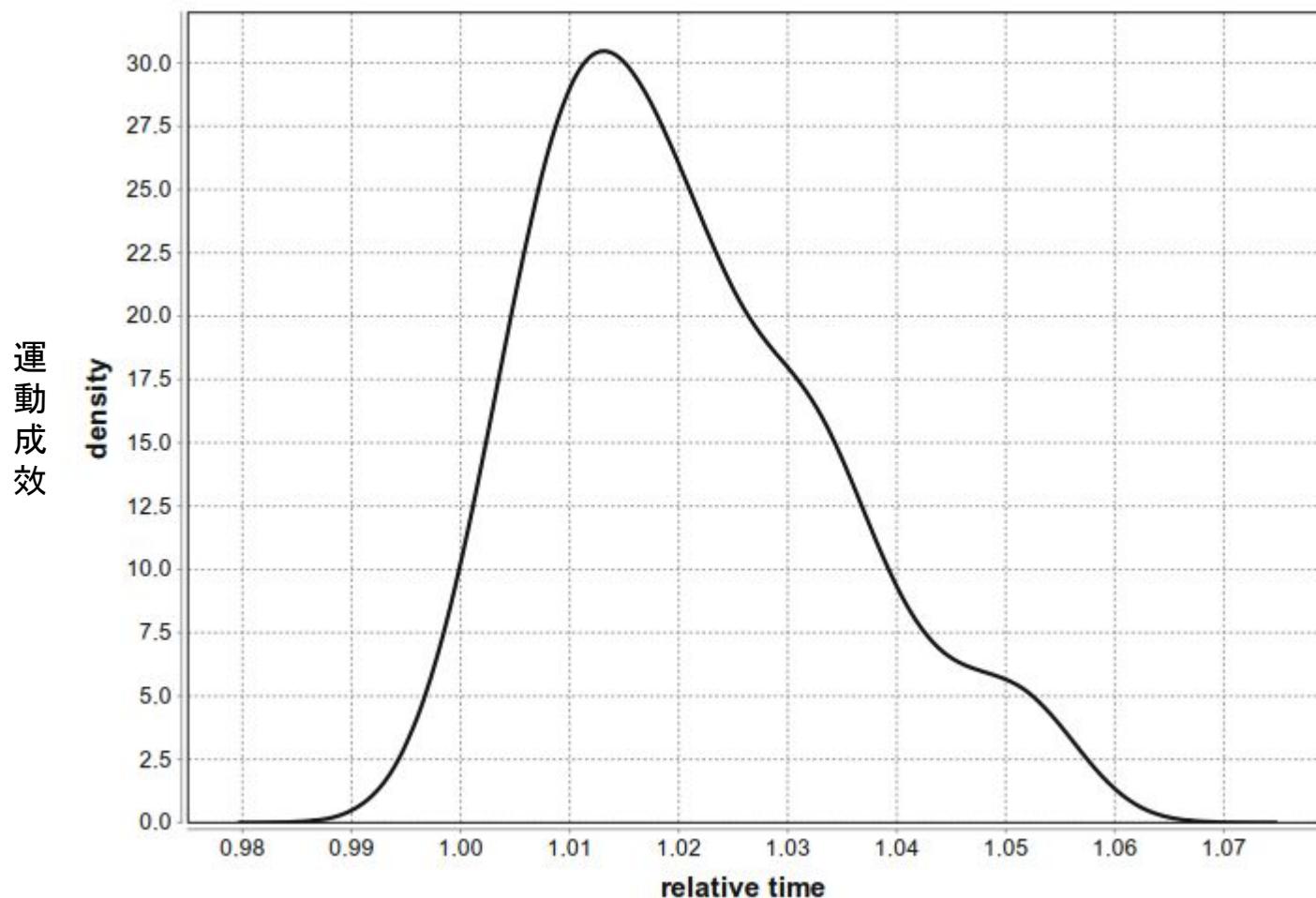


某些課程

學習時間跟期末成績無關



行為不是線性的



Knobbe, A., Orie, J., Hofman, N., van der Burgh, B., & Cachucho, R. (2017). Sports analytics for professional speed skating. *Data Mining and Knowledge Discovery*, 1–31.

大綱

1. 什麼是子群組探勘？
2. 子群組探勘的構成
3. 子群組探勘工具
4. 子群組探勘的使用案例
 - a. 使用者互動資料的子群組探勘 (2016)
 - b. 學習滿意度分析 (2014)
5. Cortana 子群組探勘實戰
 - a. 學生成效分析: 什麼樣的學生成績會比較好呢？
 - b. 學生成效分析: 找出學校跟成績有差異的子群組

什麼是子群組探勘？



原本對於資料探勘的認知

Cluster
分群

Classification
分類

Association Rule
關聯式規則



資料探勘的領域

Data Mining

資料探勘

無監督學習 Unsupervised Learning

Association Rule
關聯規則分析

Cluster
分群

Machine Learning

機器學習

Supervised Learning 監督學習

Classification
分類

Subgroup Discovery
子群組探勘

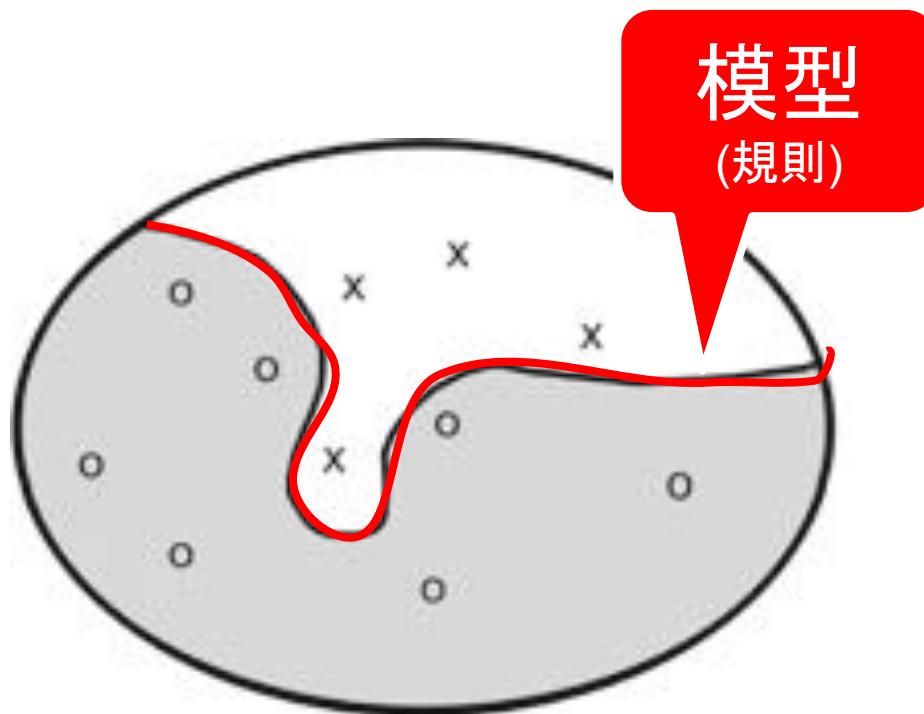
Deep Learning
深度學習

Exceptional Model Mining
特殊模型探勘

敘述型歸納 Descriptive induction

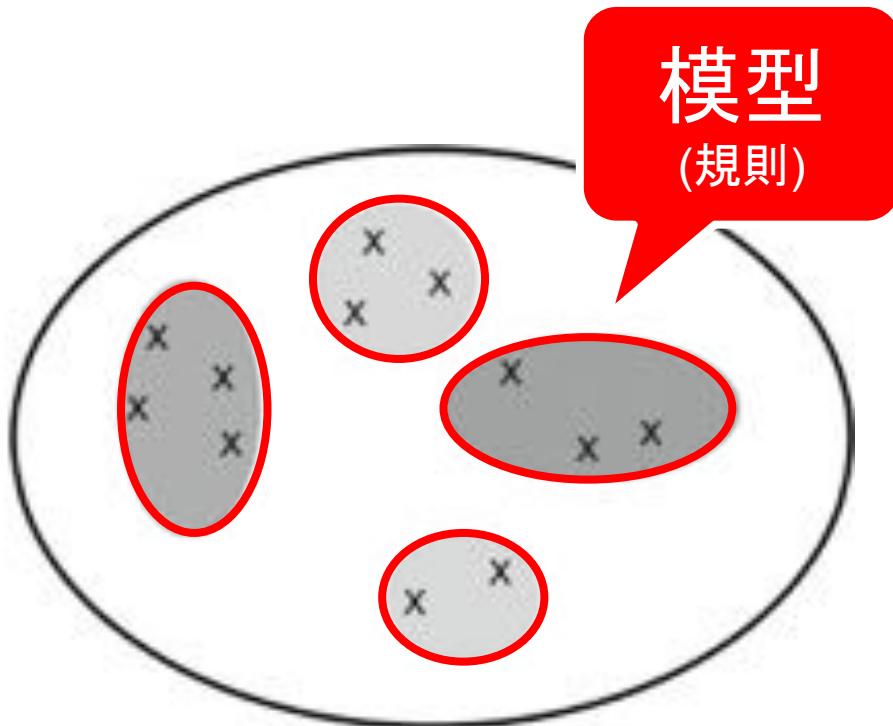
Predictive induction 預測型歸納

分類



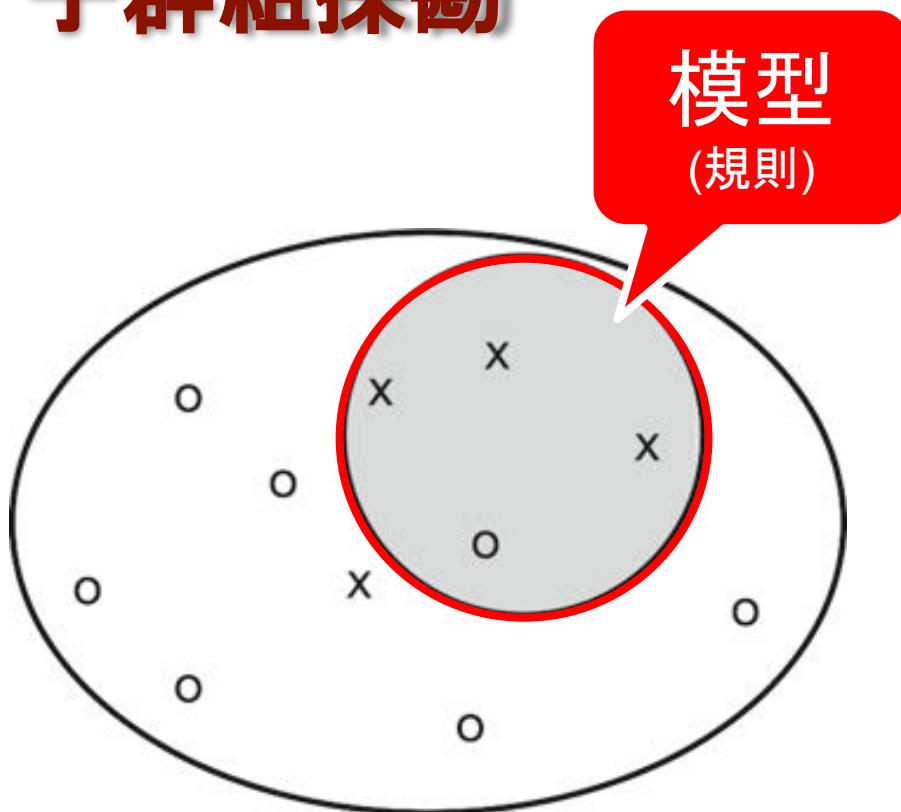
- 模型建立目標: 預測未知的新案例
 - 找出規則可以區分O跟X
 - 著重正確率跟可解釋性
 - 未來遇到未知案例時, 就能用這個規則來辨識它為O或X
- 代表性技術:
 - 決策樹
 - SVM 支持向量機
 - 類神經網路=深度學習

分群 & 關聯規則分析



- 模型建立目標: 從已知的舊案例找出整體規律模式
 - 大量的混亂資料難以解讀，我們需要找出資料的規律模式
 - 著重支持率跟信心度(有多少案例在這個分群或規則中)
 - 有了規律模式之後，我們就能更容易解釋整體資料
- 代表性技術:
 - K-Means K平均法
 - Apriori 關聯規則探勘

子群組探勘



- 模型建立目標: 根據已知的舊案例中某些目標變項, 找出單一且可解釋的規則
 - 目標變項: X
 - Q: 大部分X都有什麼特徵?
 - A: 都在圈圈右上角
 - 著重描述資料中的潛規則(知識), 而非預測
- 代表性技術:
 - PRIM (HotSpot)
 - Exceptional Model Mining (EMM)

子群組探勘近年來的主要研究者



Universiteit
Leiden

荷蘭 萊頓大學

子群組探勘的構成



子群組探勘的元件

Rule
規則

目標
研究者感興趣的變項

$R: \text{Cond} \rightarrow \text{Target}_{\text{value}}$

Condition

條件

聯合多個屬性值配對

子群組探勘的例子

資料集

特徵值域：

- 年齡 = 小於25, 25至60
, 大於60
- 性別 = 男, 女
- 國家 = 美國, 法國, 德國

目標變項值域

- 財富 = 窮, 普通, 富裕

子群組 (探勘結果)

- R_1 : (年齡=小於25 & 國家=德國)
→ 財富 = 富裕
- R_2 : (年齡=大於60 & 性別 = 女)
→ 財富 = 普通

子群組探勘的元件: 目標

目標
研究者感興趣的
變項

R: Cond \rightarrow Target_{value}

目標變項的資料類型

- 類別變項
 - 二元變項: True or False
 - 多個不同的選項
 - Ex: 實驗組/控制組
- 連續變項 (數值): 最難分析
 - 離散化 (裝箱法)
 - 最大差異法: 找尋平均數有別於整體的子群組
 - Ex: 後測成績
- 目標概念 (EMM演算法)
 - 以多個變項組成一個概念
 - 時間→成績 迴歸模型

子群組探勘的元件：敘述語言

如何呈現規則？

R: Cond \rightarrow Target_{value}

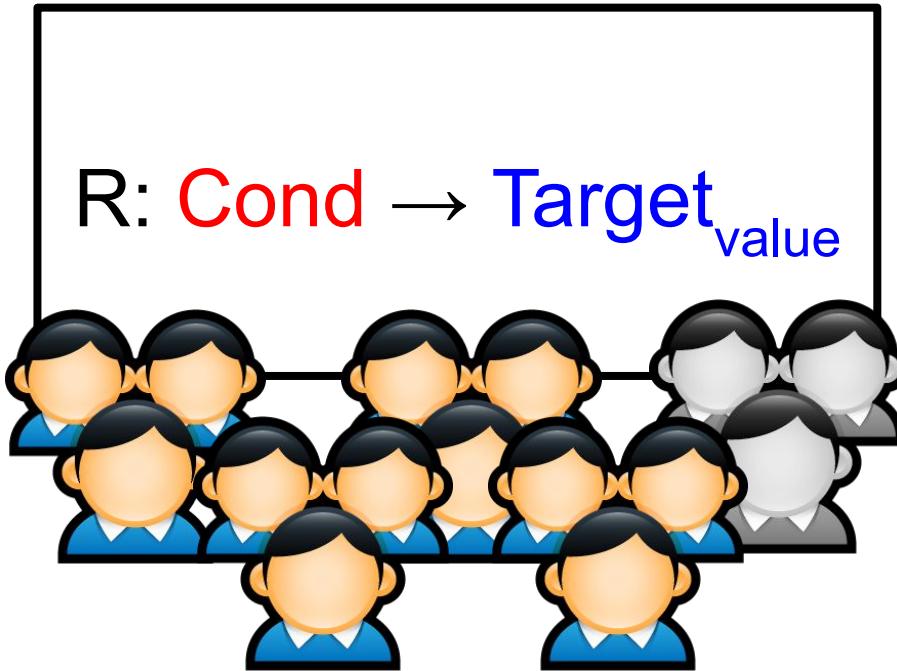
Condition

條件

聯合多個屬性值配對

- 方式：屬性值配對
 - 屬性 = 值
 - 用 & 聯合多個屬性值配對
- 屬性值配對的運算子
 - 等於 =
 - 大於、小於、或等於 > < ≥ ≤
 - 模糊邏輯 (接近高、中、低)
- 屬性的資料類型：類別、連續
- 限制
 - 深度：多少組屬性值配對？
 - 廣度：只呈現最重要的多少規則？

子群組探勘的元件：品質評估指標



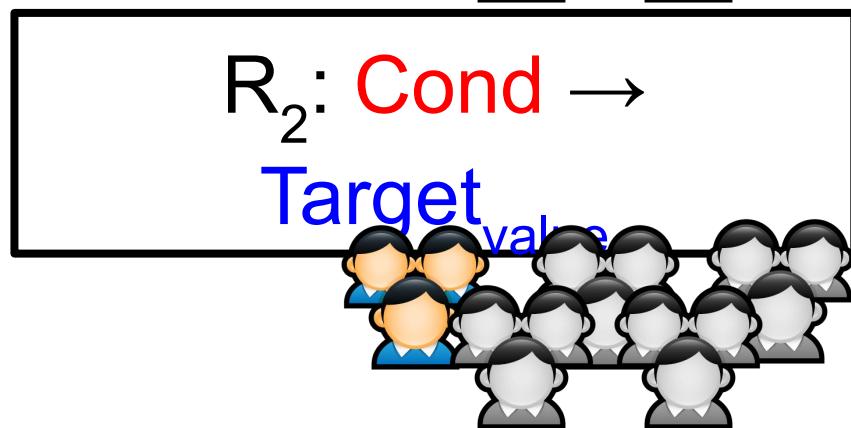
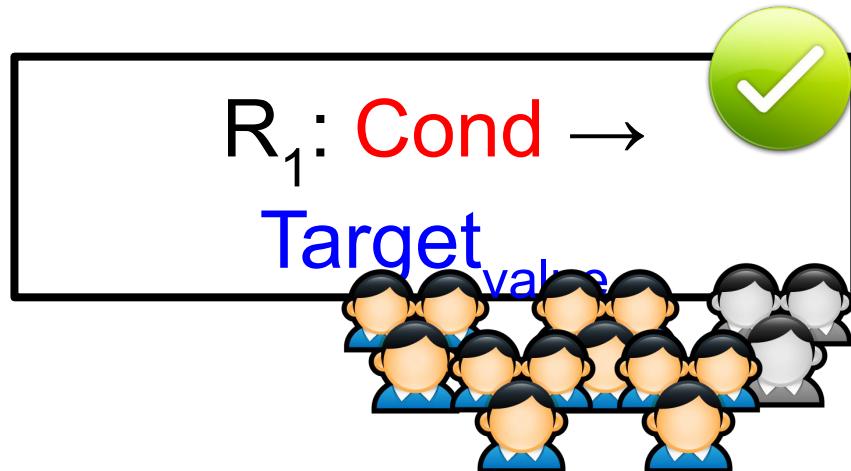
有 $12/15 = 80\%$ 的人
都符合這條規則 (涵蓋率)

何謂「好的規則」？

- 泛用指標：
 - 涵蓋率, 支持率
- 精準指標：
 - 信心度, 正確率 Q_c , 正確率 Q_g
- 值得關注指標：
 - 興趣度, 新穎度, 顯著度
- 混合指標：
 - 敏感度, 錯誤警示, 專指度, 少見度 $WRAcc$

沒有最好的指標！

子群組探勘的元件:搜尋策略



如何找到「好的規則」？

- 窮盡演算法 & 篩選
- 啟發式演算法
- 收束搜尋 Beam search
- 演化式演算法:基因演算法

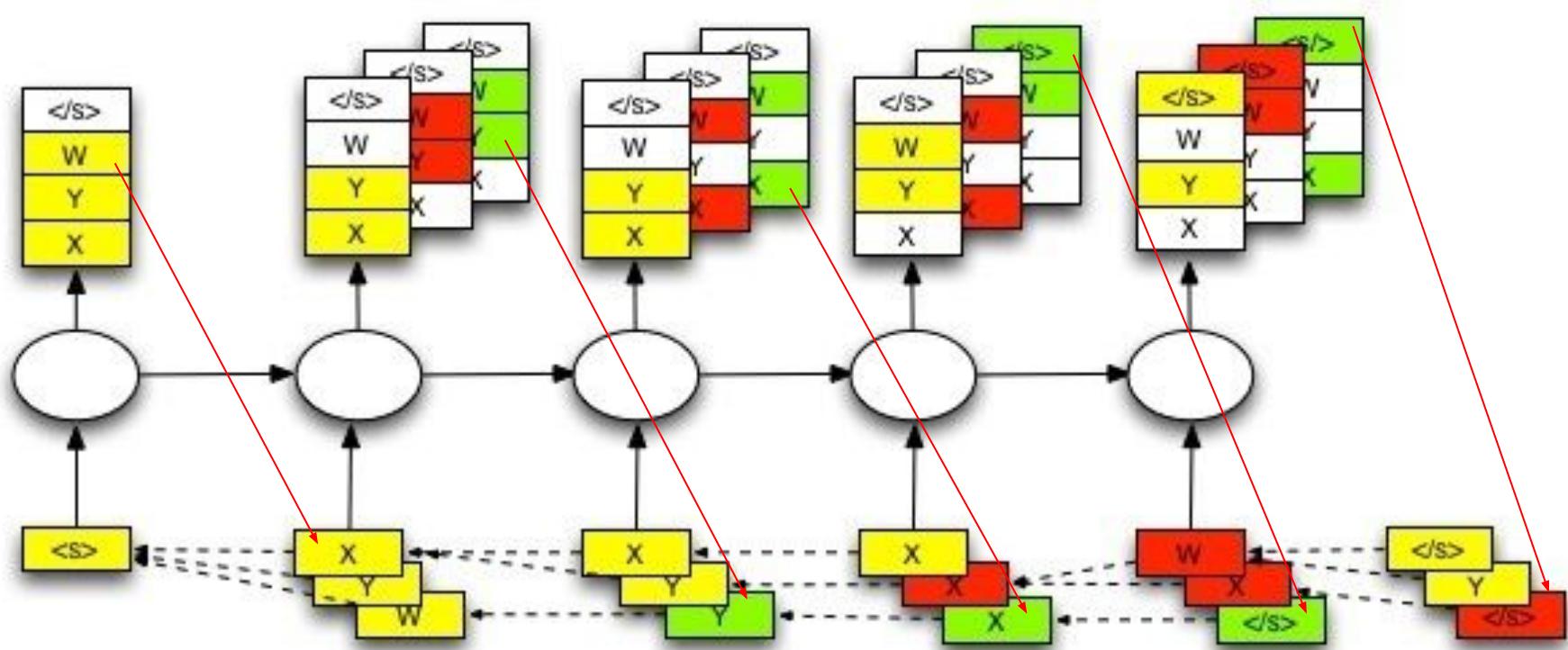
如何處理連續變項？

- 離散化
- 模糊邏輯

指標改進多少才是好的規則？

- 最小進步門檻

收束搜尋 Beam search



- 設定候選規則欄位 : 3
- 每次搜尋過程中，不斷選擇最佳的3個候選規則，剔除不佳者

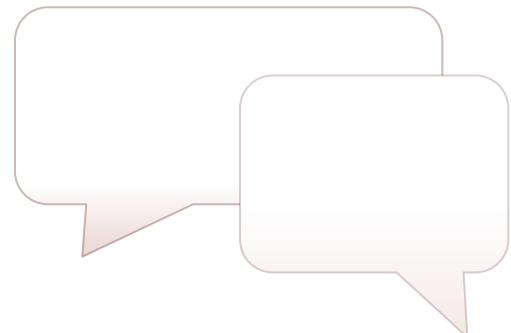
<https://www.quora.com/Why-is-beam-search-required-in-sequence-to-sequence-transduction-using-recurrent-neural-networks>

子群組探勘工具

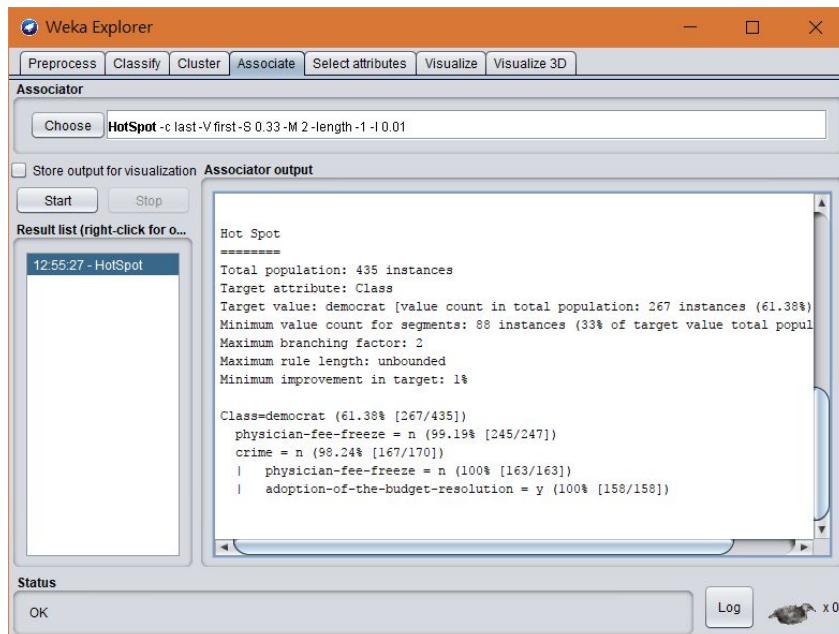


工具列表

- Explora
- KEPLER
- Subgroup Miner
- RapidMiner
- Knime
- Weka的HotSpot
- Orange
- KEEL
- VIKAMIME
- Cortana

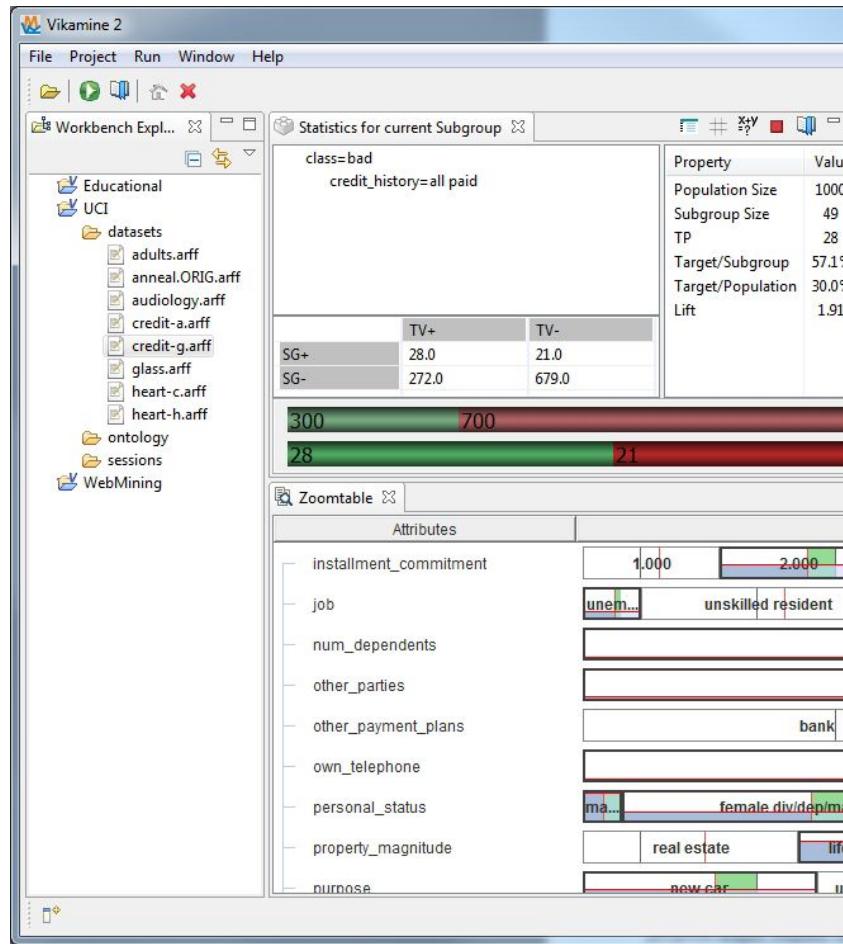


Weka的HotSpot (2013)



- 演算法: PRIM (HotSpot)
- 目標:
 - 只能一個變項
 - 類別變項
- 連續變項特徵處理:
 - 連續變項 (平均值二分法)
 - 手動離散化
- 品質評估指標:
 - 涵蓋率, 信賴度, 增益度, 影響度, 肯定度 (關聯規則分析的指標)
- 互動性跟解讀性差

VIKAMIME (2016)



- 演算法：

- SDMAP (廣度最佳),
BitSetSD, Beam Search,
Simple DFS (深度最佳)

- 目標：

- 只能一個變項
- 類別/連續變項

- 連續變項特徵處理

- 自動離散化(有待調查?)
- 手動離散化：裝箱/分群

- 品質評估指標：

- 涵蓋率, 正確率, 影響度, 顯著度

- 互動性跟解讀性極佳

VIKAMIME 操作界面 (1/3)

VIKAMIME 2

File Project Run Window Help

Workbench Expl... Statistics for current Subgroup Subgroup Workspace Attribute Navigator

Interactive

Subgroup workspace Result@13.10.15,13:56- Result@13.10.15,13:56-

Subgroup / Subgroup Size Target/Su... Target-Filter

Subgroup /	Subgroup Size	Target/Su...	Target-Filter
credit_history=all paid AND foreign_worker=ye	48	58.3%	...
credit_history=all paid AND foreign_worker=ye	41	61.0%	...
credit_history=all paid AND foreign_worker=ye	24	75.0%	...
credit_history=all paid AND num_dependents=1	35	60.0%	2 ...
credit_history=all paid AND other_parties=none	41	61.0%	...
credit_history=all paid AND other_parties=none	41	61.0%	...

Statistics for current Subgroup

Property Value

Property	Value
Population Size	1000
Subgroup Size	49
TP	28
Target/Subgroup	57.1%
Target/Population	30.0%
Lift	1.91

SG+ SG- TV+ TV- 300 700 28 21

Subgroup Workspace

Zoomable

Attributes Values

Attributes	Values
installment_commitment	1.000 2.000 3.000 4.000
job	unem... unskilled resident skilled high qualif/sef emp/m...
num_dependents	1.000 2.000
other_parties	none co-ap... guarantor
other_payment_plans	bank stores none
own_telephone	none yes
personal_status	ma... female div/dep/mar male single ma...
property_magnitude	real estate life insurance car no known property
numorse	new car used car furniture/equipment radio/tv educa... ref... business oth...

Attribute Navigator

- All Attributes
 - ID
 - age
 - checking_status
 - class
 - credit_amount
 - credit_history
 - duration
 - employment
 - existing_credits
 - foreign_worker
 - housing
 - installment_commitment
 - job
 - num_dependents
 - other_parties
 - other_payment_plans
 - own_telephone
 - personal_status
 - property_magnitude
 - purpose
 - residence_since
 - savings_status
- Zoomable
 - checking_status
 - credit_history
 - installment_commitment
 - job
 - num_dependents
 - other_parties
 - other_payment_plans

VIKAMIME 操作界面 (2/3)

The screenshot shows the Vikamine 2 software interface with several windows open:

- Workbench Expl...:** Shows a tree view of datasets, including Educational, UCI, and WebMining categories with various files like adults.arff, anneal.ORI, and heart-h.arff.
- Statistics for current Subgroup:** Displays subgroup statistics for "class=bad credit_history=all paid".

Property	Value
Population Size	1000
Subgroup Size	49
TP	28
Target/Subgroup	57.1%
Target/Population	30.0%
Lift	1.91
- Subgroup Workspace:** Shows the "Subgroup workspace" with the result from 13.10.15, 13:56. It lists subgroups:
 - credit_history=all paid AND foreign
 - credit_history=all paid AND foreign
- Attribute Navigator:** Lists all attributes with their data types:
 - All Attributes
 - ID
 - age
 - checking_status
 - class
 - credit_amount
 - credit_history
 - duration
 - employment
 - existing_credits
 - foreign_worker
 - housing
 - installment_commitment
 - job
 - num_dependents
 - other_parties
 - other_payment_plans
 - own_telephone
 - personal_status
 - property_magnitude
 - purpose
 - residence_since
 - savings_status
 - Zoomtable
 - checking_status
 - credit_history
 - installment_commitment
 - job
 - num_dependents
 - other_parties
 - other_payment_plans
- Zoomtable:** A data visualization tool showing the distribution of attributes like "installment_commitment", "job", and "personal_status". Each attribute has a horizontal bar with colored segments representing different values or categories.

Three large red callout boxes highlight specific features:

- 檔案 (File):** Points to the "Workbench Expl..." window.
- 資料屬性 (Data Attributes):** Points to the "Attribute Navigator" window.
- 資料分佈分析 (Data Distribution Analysis):** Points to the "Zoomtable" window.

VIKAMIME 操作界面 (3/3)

The screenshot displays the VIKAMIME 2 software interface with the following components:

- File Project Run Window Help**: The top menu bar.
- Workbench Expl... Statistics for current Subgroup**: A panel showing statistics for the current subgroup. It includes:
 - Properties: class=bad, credit_history=all paid
 - Population Size: 1000
 - Subgroup Size: 49
 - TP: 28
 - Target/Subgroup: 57.1%
 - Target/Population: 30.0%
 - Lift: 1.91

	TV+	TV-
SG+	28.0	21.0
SG-	272.0	679.0

Two horizontal bar charts at the bottom show proportions: 300 (red) and 28 (green).
- Subgroup Workspace**: A panel showing the results of subgroup workspace analysis. It includes:
 - Result@13.10.15,13:56- (Subgroup workspace)
 - Table: Subgroup / Subgroup Size Target/Su...
Detailed data:
 - + credit_history=all paid AND foreign_worker=ye 48 58.3% 1 ...
 - + credit_history=all paid AND foreign_worker=ye 41 61.0% 1 ...
 - + credit_history=all paid AND foreign_worker=ye 24 75.0% 1 ...
 - + credit_history=all paid AND num_dependents]- 35 60.0% 2 ... 1 ...
 - + credit_history=all paid AND other_parties=none 41 61.0% 1 ...
 - + credit_history=all paid AND ... 41 61.0% 1 ...
- Attribute Navigator**: A panel listing all attributes:
 - All Attributes
 - ID
 - age
 - checking_status
 - class
 - credit_amount
 - credit_history
 - duration
 - employment
 - existing_credits
 - foreign_worker
 - housing
 - installment_commitment
 - job
 - num_dependents
 - other_parties
 - other_payment_plans
 - own_telephone
 - personal_status
 - property_magnitude
 - purpose
 - residence_since
 - savings_status
 - Zoomtable
 - checking_status
 - credit_history
 - installment_commitment
 - job
 - num_dependents
 - other_parties
 - other_payment_plans
- Zoomtable**: A panel showing a zoomed-in view of attribute data. It includes:
 - Attributes: bank, stores, none, cc_ap..., guarantor
 - Values: bank, stores, none, yes, male single, male single, real estate, life insurance, car, no known property, new car, used car, furniture/equipment, radio/tv, education, ref..., business, other
- Red Callout Labels**: Two red callout labels are present:
 - 規則分析 (Rule Analysis) pointing to the 'Statistics for current Subgroup' panel.
 - 子群組探勘結果 (Subgroup Exploration Results) pointing to the 'Subgroup Workspace' panel.

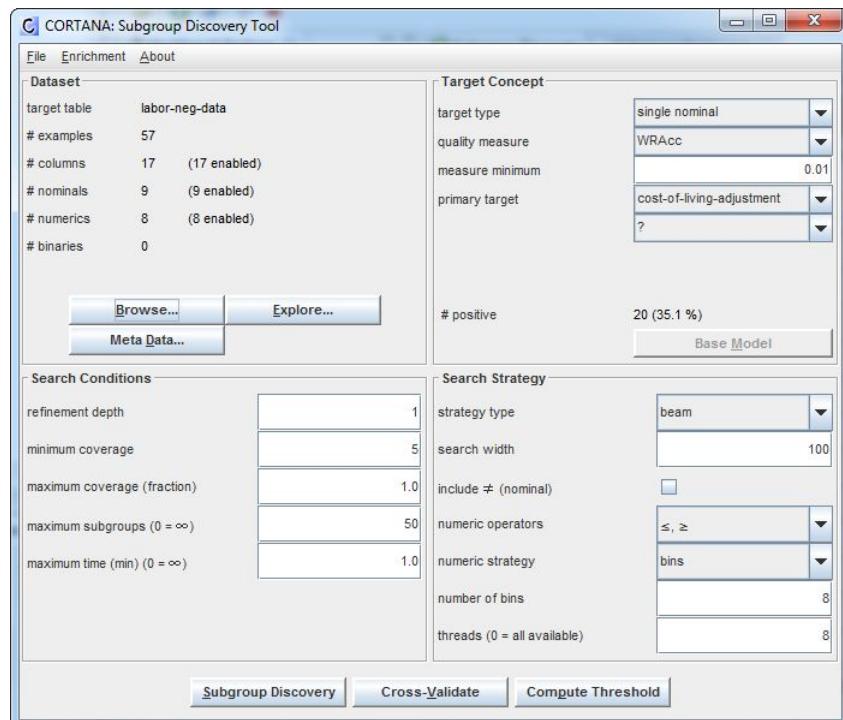
VIKAMIME 探勘結果

品質=跟整體相比，子群組的指標改進程度

顯著性=規則的不隨機性

Subgroup	Quality	Popul...	Subgr...	Targe...	Targe...	Lift	Signif...	Cluster	TP / FP
class=good									
contribution-to-dental-plan=full	4.561	57	13	100.0%	64.9%	1.541	≤ 0.01 ...	1	13
contribution-to-health-plan=full AND contribution-to-dental-plan=full	2.807	57	8	100.0%	64.9%	1.541	≤ 0.1 ...	1	8
contribution-to-dental-plan=full									
contribution-to-health-plan=full									
duration[1.5;2.5[AND contribution-to-dental-plan=full	3.158	57	9	100.0%	64.9%	1.541	≤ 0.05 ...	1	9
statutory-holidays[10.5;11.5[AND contribution-to-dental-plan=full	2.807	57	8	100.0%	64.9%	1.541	≤ 0.1 ...	1	8
vacation=generous	3.614	57	16	87.5%	64.9%	1.348	≤ 0.05 ...	999	14 TP, 2 FP
wage-increase-first-year[4.15;4.8[	2.86	57	11	90.9%	64.9%	1.4	≤ 0.1 ...	999	10
wage-increase-first-year[4.8;∞[	4.211	57	12	100.0%	64.9%	1.541	≤ 0.05 ...	999	12
wage-increase-second-year[3.75;4.2[	2.807	57	8	100.0%	64.9%	1.541	≤ 0.1 ...	999	8
wage-increase-second-year[4.2;4.9[	3.158	57	9	100.0%	64.9%	1.541	≤ 0.05 ...	999	9
working-hours]-∞;36.5[	2.86	57	11	90.9%	64.9%	1.4	≤ 0.1 ...	999	10 TP, 1 FP

CORTANA (2013)



- 演算法: **EMM**
 - Beam Search, 深度優先, 廣度優先
- 目標:
 - 一個/二個變項, 多變項
 - 類別/連續變項
- 連續變項特徵處理
 - 自動離散化: 裝箱法
- 品質評估指標:
 - 眾多指標
- 用推論統計決定最佳參數設定
- 互動性跟解讀性普通

CORTANA 探勘結果

C 9 subgroups found; target table = labor-neg-data; quality measure = WRAcc; target value = go...

Nr.	Depth	Coverage	Quality	Probability	Positives	p-Value	Conditions
1	1	30	0.149584	0.933333	28	9.325873...	pension = '?'
2	1	39	0.134811	0.846154	33	4.589414...	wage-increase-first-year >= '3.0'
3	1	31	0.120652	0.870968	27	4.620461...	wage-increase-second-year >= '4.0'
4	1	22	0.117882	0.954545	21	1.921927...	wage-increase-first-year >= '4.5'
5	1	29	0.108341	0.862069	25	0.0103455	wage-increase-first-year >= '4.0'
6	1	37	0.104955	0.810811	30	0.030420...	wage-increase-second-year >= '3.0'
7	1	18	0.093259	0.944444	17	0.360048...	shift-differential >= '4.0'
8	1	37	0.087411	0.783784	29	0.655359...	statutory-holidays >= '11.0'
9	1	45	0.084026	0.755556	34	0.7992004	wage-increase-first-year >= '2.5'

ROC Browse Selected Delete Selected Gaussian p-Values

Close

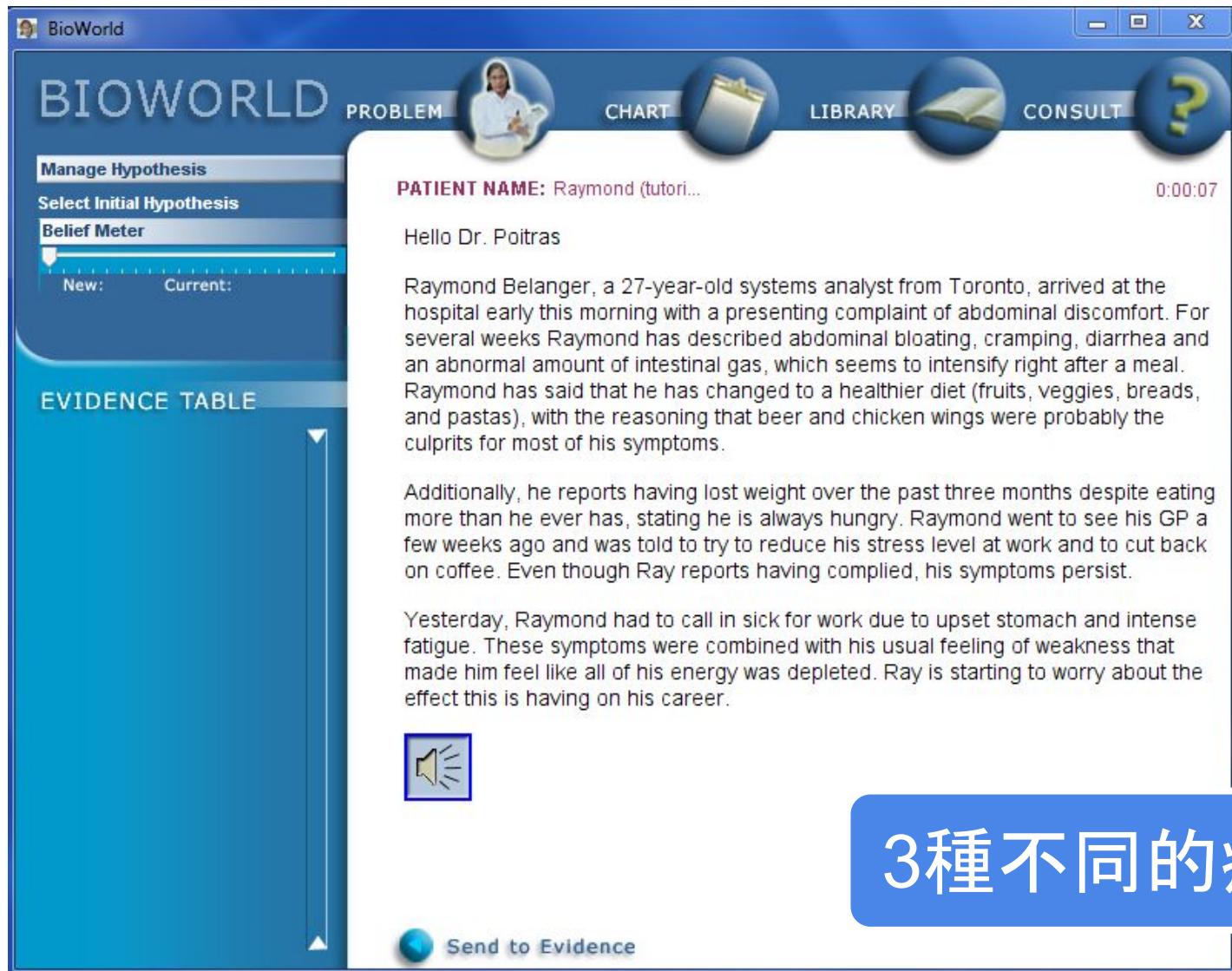
子群組探勘的使用案例A

使用者互動資料的子群組探勘 (2016)



Poitras, E. G., Lajoie, S. P., Doleck, T., & Jarrell, A. (2016). Subgroup discovery with user interaction data: An empirically guided approach to improving intelligent tutoring systems. *Journal of Educational Technology & Society*, 19(2), 204.

BIOWORLD: 醫生模擬訓練系統



The screenshot shows the BioWorld software interface. At the top, there is a menu bar with the BioWorld logo and a toolbar with icons for Problem, Chart, Library, and Consult. The main window displays a patient consultation for Raymond Belanger. The patient's name is listed as Raymond (tutor...). The time is 0:00:07. A greeting message says "Hello Dr. Poitras". The patient's history is described: Raymond Belanger, a 27-year-old systems analyst from Toronto, arrived at the hospital early this morning with a presenting complaint of abdominal discomfort. For several weeks Raymond has described abdominal bloating, cramping, diarrhea and an abnormal amount of intestinal gas, which seems to intensify right after a meal. Raymond has said that he has changed to a healthier diet (fruits, veggies, breads, and pastas), with the reasoning that beer and chicken wings were probably the culprits for most of his symptoms. Additionally, he reports having lost weight over the past three months despite eating more than he ever has, stating he is always hungry. Raymond went to see his GP a few weeks ago and was told to try to reduce his stress level at work and to cut back on coffee. Even though Ray reports having complied, his symptoms persist. Yesterday, Raymond had to call in sick for work due to upset stomach and intense fatigue. These symptoms were combined with his usual feeling of weakness that made him feel like all of his energy was depleted. Ray is starting to worry about the effect this is having on his career. A speaker icon indicates that there is audio content available. At the bottom of the screen, there is a blue button labeled "Send to Evidence".

3種不同的病患

BIOWORLD操作步驟

主要操作

1. 閱讀病患自述狀況
 - a. 閱讀一連串病患的自述
 - b. 選擇自述中值得注意的重點 (標註) + 信心程度
加入到證據表中
2. 檢查病患狀況
 - a. 選擇要檢測的項目
 - b. 獲得檢測結果
3. 診斷疾病

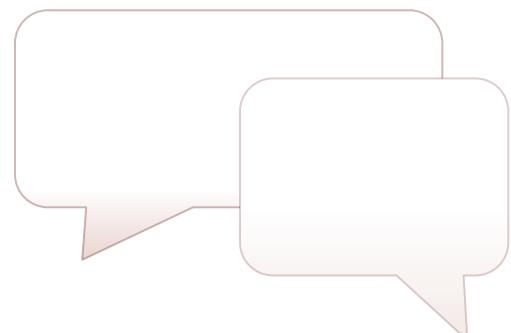
輔助功能

- 疾病資料庫
 - 可以查詢某些疾病可能有的特徵
- 求助工具
 - 取得提示

Novice-Expert overlay Model

新手-專家重疊模型：如何改進？

- 先前的研究指出：新手跟老手的操作是有差別的
- Bioworld想要結合新手專家重疊模型來作為指引新手的指示
- 問題聚焦
 - 什麼樣的檢查結果，會導向錯誤的診斷？
 - 這些困難問題的影響是什麼？



子群組分析結果 罕見疾病 嗜鉻細胞瘤 案例誤判規則

Table 2. Patterns extracted from the subgroup discovery algorithm

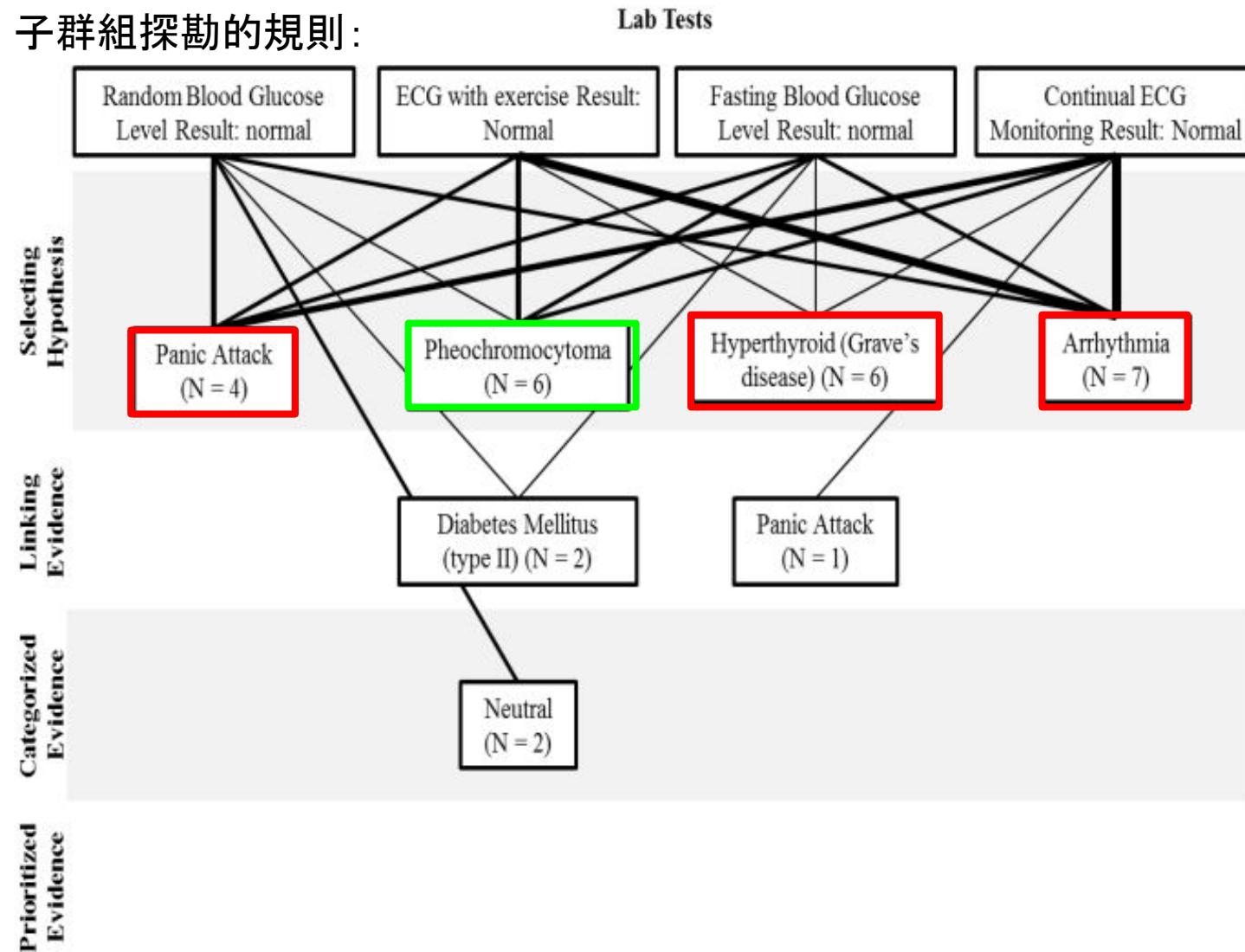
Antecedent	1	2	3	4	5	6
<i>Incorrect diagnosis for the Cynthia case (i.e., exhibiting signs of Pheochromocytoma)</i>						
Random Blood Glucose Level Result: normal=true	5	1	6	6.1%	83.3%	43.9%
Continual ECG Monitoring Result: Normal=true	9	2	11	11.2%	81.8%	46.9%
Fasting Blood Glucose Level Result: normal=true	5	2	7	7.1%	71.4%	42.9%
ECG with exercise Result: Normal=true	7	3	10	10.2%	70.0%	43.9%

Note. 1 = Positive instances; 2 = Negative instances; 3 = Size; 4 = Coverage; 5 = Precision; 6 = Accuracy.

- 看到檢查結果之後誤判疾病的規則
- Random Blood Glucose Level Result: normal=true
 - 6個人進行此檢查
 - 5個人判斷疾病錯誤 (正面案例)
 - 1個人判斷疾病正確 (負面案例)
- 可以據此改善新手-專家重疊模型, 加入更多提示

規則細部分析 診斷錯的情況還做了什麼事情？

子群組探勘的規則：



子群組探勘的使用案例B

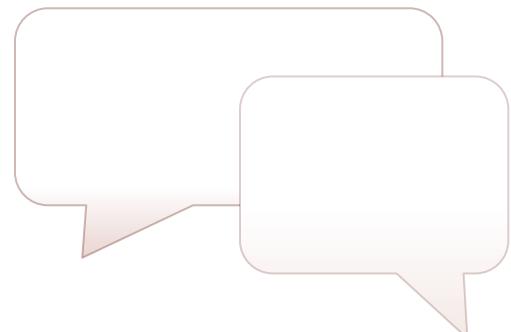
學習滿意度分析 (2014)



Lemmerich, F. (2014). Novel Techniques for Efficient and Effective Subgroup Discovery, Neue Techniken für effiziente und effektive Subgruppenentdeckung. Würzburg, Univ., Germany. Retrieved from
<https://opus.bibliothek.uni-wuerzburg.de/frontdoor/index/index/docId/9781>

資料蒐集

- 學生的期末學習課程滿意度調查
- 類別變項
 - 課程
 - 學院
 - 學位
- 連續變項
 - 各種滿意度: 1最佳、6最不滿意
 - 學生背景調查: 學習時間、是否工讀等等
- 共有119個特徵, 2800份填答



整體分析

Description	# Students	Mean satisfaction
<i>Overall</i>	2799	2.61
Matching requirem. = [4-6]	258	3.46
Matching requirem. = [4-6] \wedge Information = [4-6]	55	3.93
Overcrowded courses = true	887	2.89
Overlapping courses = true	1030	2.85
Degree program = Medicine	321	2.24
Degree program = Medicine \wedge Semester = [1-2]	70	1.93

- 比整體更不滿意的子群組規則
 - 不符合要求條件、課程未充分告知、課堂擁擠、衝堂
- 比整體更滿意的子群組規則
 - 醫學系、第1-2學期

性別x學習滿意度:指標定義

- 定義新的品質評估指標:

$$q_{meanDiff}^a(P) = i_P \cdot ((\mu_{F \wedge P} - \mu_{M \wedge P}) - (\mu_F - \mu_M))$$

- 考慮變數
 - 整體的男女學習滿意度平均值差異
 - 符合子群組規則的男女學習滿意度平均值差異
 - 子群組符合的案例數量

性別x學習滿意度:探勘結果

- 某自然科學的課堂
 - 整體滿意度 2.5
 - 40位男生滿意度 2.25
 - 24位女生滿意度 2.96
 - 但不是每堂自然科學課程都是如此
- 需要每週20小時讀書 & 交通時間1小時
 - 10位男生滿意度 2.2
 - 27位女生滿意度 2.93

對實驗室分析方法的啟示

某些背景變項

- 需要每週20小時讀書 & 交通時間1小時

- 10位男生滿意度 2.2
- 27位女生滿意度 2.93

學習成效

實驗組/控制組

Cortana 子群組探勘實戰A

學生成效分析

什麼樣的學生成績會比較好呢？



資料集

- 取自UCI機器學習保存庫中的「Student Performance Data Set」
- 葡萄牙的兩所中學的學生成績跟學生的背景變項
 - 學生的家庭
 - 學生的學校表現
 - 學生的最後一學期的成績

為了方便解說，我修改了部分資料內容

<https://docs.google.com/spreadsheets/d/1aHRvPB2RJFseQYMS9j-sFQHlcqNY3os8IxwiEaPo9iA/edit?usp=sharing>

<http://archive.ics.uci.edu/ml/datasets/Student+Performance>

特徵說明 (1/3)

- school 學校: 實驗組學校(2), 控制組學校(1)
- sex 性別: F, M
- age 年齡: 15~22
- address 居住處: U都市, R鄉村
- famsize 家庭人數: ≤ 3 , > 3
- Pstatus 雙親狀態: 同居, 分居
- Medu 母親教育: 未受教育0~4高等教育
- Fedu 父親教育: 未受教育0~4高等教育
- Mjob 母親職業: teacher, health, civil, at_home, other
- Fjob 母親職業: teacher, health, civil, at_home, other
- reason 選校理由: home 近家, reputation 學校名聲, course 優質課程, other

特徵說明 (2/3)

- guardian 學生監護人: mother, father, other
- traveltime 學校交通時間(min): (1)1~15, (2)15~30, (3)30~60, (4)>60
- studytime 每週學習時間(hour): (1)<2, (2)2~5, (3)5~10, (4)>10
- failures 課程犯錯次數: 0~4
- schoolsup 學校教育補助: yes,no
- famsup 家庭教育補助: yes,no
- paid 其他補習課程: yes, no
- activities 其他課程活動: yes, no
- nursery 是否去托兒所: yes, no
- higher 是否想上高等教育: yes, no

特徵說明 (3/3)

- internet 家裡能上網嗎: yes, no
- romantic 戀愛中: yes, no
- famrel 與家人的關係: 非常糟1~5非常好
- freetime 課後空閒時間: 非常少1~5非常多
- goout 跟朋友出遊: 非常少1~5非常多
- Dalc 工作日喝酒: 非常少1~5非常多
- Walc 週末喝酒: 非常少1~5非常多
- health 現在健康狀況: 非常糟1~5非常好
- absences 缺席次數: 0~93
- grade3 最後一學期成績: 0~20

什麼樣特徵的學生，成績會較好呢？

CORTANA: Subgroup Discovery Tool

File Enrichment About

Dataset

target table student-por - data
examples 313
columns 31 (31 enabled)
nominals 8 (8 enabled)
numerics 14 (14 enabled)
binaries 9 (9 enabled)

Browse... Explore... Meta Data...

Search Conditions

refinement depth 1
minimum coverage 31
maximum coverage (fraction) 1.0
maximum subgroups (0 = ∞) 10
maximum time (min) (0 = ∞) 1.0

Target Concept

target type single numeric
quality measure Average
measure minimum 12.102237
primary target final_grade

average 12.102237

Base Model

Search Strategy

strategy type beam
search width 100
include \neq (nominal)
numeric operators \leq, \geq
numeric strategy bins
number of bins 8
threads (0 = all available) 8

Subgroup Discovery Cross-Validate Compute Threshold

目標：要找出比整體平均值高的子群組

什麼樣特徵的學生，成績會較好呢？

C 10 subgroups found; target table = student-por - data; quality measure = Z-Score

Nr.	Depth	Coverage	Quality	Average	St. Dev.	p-Value	Conditions
1	1	88	4.133197	13.147...	2.395734	-	Medu >= '4.0'
2	1	34	3.868419	13.676...	2.284482	-	Mjob = 'teacher'
3	1	147	2.953506	12.680...	2.291618	-	Medu >= '3.0'
4	1	124	2.926311	12.725...	2.631505	-	absences <= '0.0'
5	1	60	2.713013	12.933...	2.462158	-	Fedu >= '4.0'
6	1	62	2.55091	12.870...	2.225105	-	reason = 'reputation'
7	1	273	2.425353	12.450...	2.211842	-	failures <= '0.0'
8	1	69	2.331014	12.768...	2.233765	-	studytime >= '3.0'
9	1	127	2.244345	12.574...	2.253675	-	Fedu >= '3.0'
10	1	197	2.217673	12.477...	2.283407	-	Walc <= '2.0'

[Browse Selected](#) [Delete Selected](#) [Save](#) [Print](#)

[Close](#)

母親教育在大學以上時，子群組的成績平均值為較高的13.14！

什麼樣特徵的學生，成績會較 差呢？

C CORTANA: Subgroup Discovery Tool

File Enrichment About

Dataset

target table student-por - data
examples 313
columns 31 (31 enabled)
nominals 8 (8 enabled)
numerics 14 (14 enabled)
binaries 9 (9 enabled)

Browse... Explore... Meta Data...

Search Conditions

refinement depth 1
minimum coverage 31
maximum coverage (fraction) 1.0
maximum subgroups (0 = ∞) 10
maximum time (min) (0 = ∞) 1.0

Target Concept

target type single numeric
quality measure Inverse Average
measure minimum -12.102237
primary target final_grade

average 12.102237

Base Model

Search Strategy

strategy type beam
search width 100
include \neq (nominal)
numeric operators \leq, \geq
numeric strategy bins
number of bins 8
threads (0 = all available) 8

Subgroup Discovery Cross-Validate Compute Threshold

目標：要找出比整體平均值低的子群組

什麼樣特徵的學生，成績會較 差呢？

C 10 subgroups found; target table = student-por - data; quality measure = Inverse Average

Nr.	Depth	Coverage	Quality	Average	St. Dev.	p-Value	Conditions
1	1	40	-9.725	9.725	2.012306	-	failures >= '1.0'
2	1	59	-11	11	2.428643	-	Walc >= '4.0'
3	1	42	-11.142...	11.142...	2.133312	-	absences >= '8.0'
4	1	75	-11.293...	11.293...	2.507447	-	Medu <= '1.0'
5	1	71	-11.309...	11.309...	2.526432	-	Mjob = 'at_home'
6	1	104	-11.375	11.375	1.892229	-	studytime <= '1.0'
7	1	79	-11.379...	11.379...	2.517301	-	Fedu <= '1.0'
8	1	42	-11.428...	11.428...	1.74769	-	schoolsups = '1'
9	1	116	-11.465...	11.465...	2.375997	-	Walc >= '3.0'
10	1	92	-11.478...	11.478...	2.040238	-	Dalc >= '2.0'

[Browse Selected](#) [Delete Selected](#) [Save](#) [Print](#)

[Close](#)

課堂犯錯1次以上的學生，子群組的成績平均值為較低的9.725！

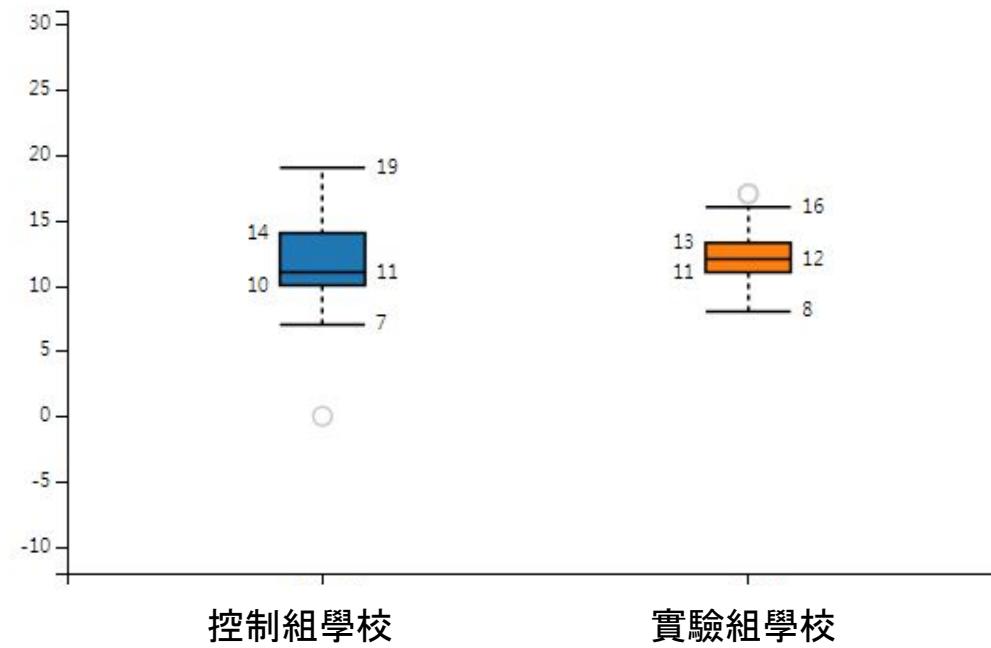
Cortana 子群組探勘實戰B

學生成效分析

找出學校跟成績有差異的子群組



兩所學校的學生成績比較

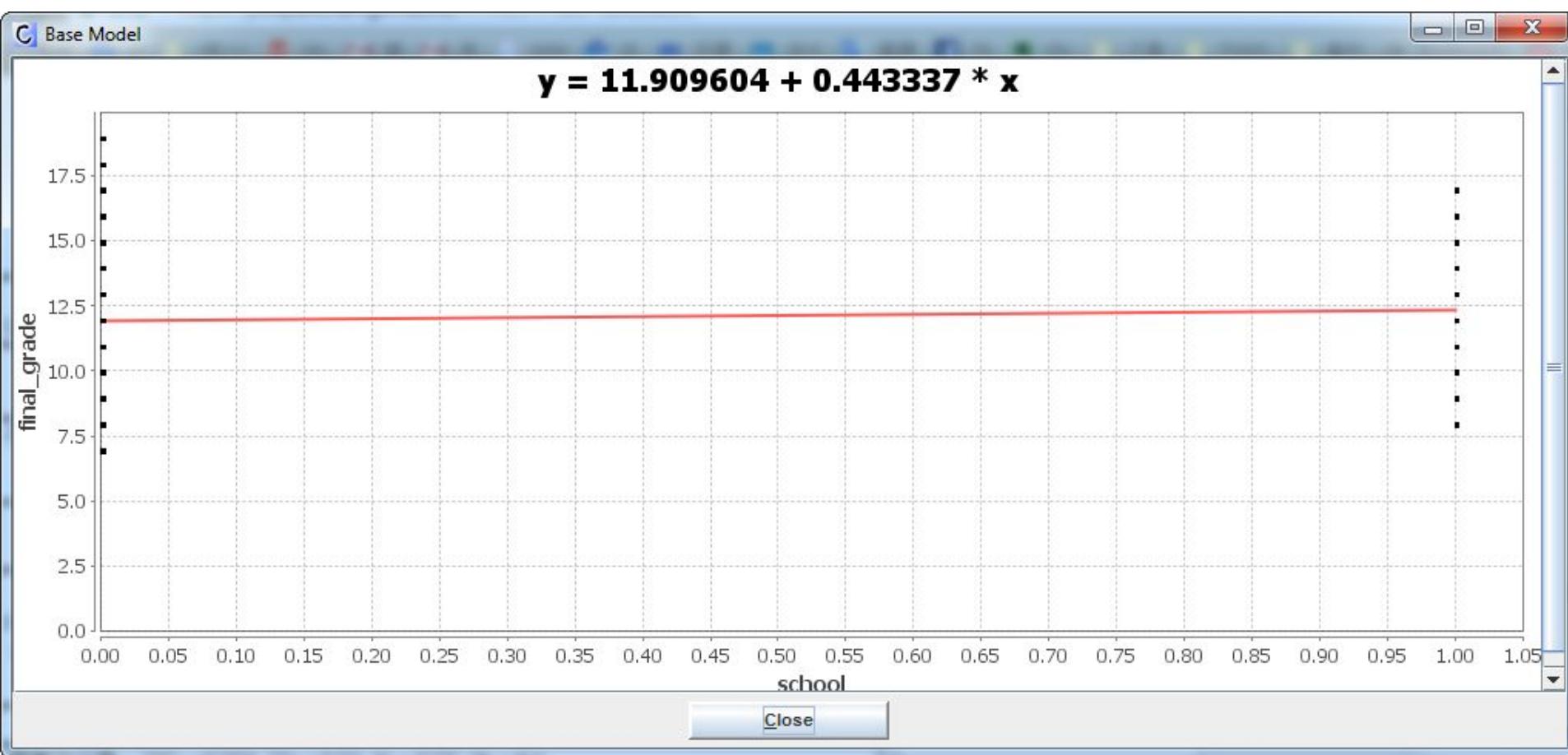


實驗組學校: 136位學生, 平均成績12.3529

控制組學校: 177位學生, 平均成績11.9096

t 值1.64, p 值0.1, 差異未達顯著

基礎模型



看不出什麼差別

從學校能否預測成績呢？(迴歸)

CORTANA: Subgroup Discovery Tool

File Enrichment About

Dataset

target table	student-por - data
# examples	313
# columns	31 (31 enabled)
# nominals	8 (8 enabled)
# numerics	15 (15 enabled)
# binaries	8 (8 enabled)

Target Concept

target type	double regression
quality measure	Significance of Slope Differ...
measure minimum	0.0
primary target	school
	final_grade

correlation 0.09276096222506662

Base Model

Search Conditions

refinement depth	1
minimum coverage	31
maximum coverage (fraction)	1.0
maximum subgroups (0 = ∞)	10
maximum time (min) (0 = ∞)	1.0

Search Strategy

strategy type	beam
search width	100
include \neq (nominal)	<input type="checkbox"/>
numeric operators	\leq, \geq
numeric strategy	bins
number of bins	8
threads (0 = all available)	8

Subgroup Discovery Cross-Validate Compute Threshold

用學校來預測成績

自由時間多寡似乎容易影響成績

C 10 subgroups found; target table = student-por - data; quality measure = Signif...

Nr.	De...	Covera...	Quality	Slope	Intercept	p-Value	Conditions
1	1	42	2.5127...	-1.010	12.222...	-	schoolsup = '1'
2	1	123	2.4984...	1.2606...	11.25	-	freetime >= '4.0'
3	1	88	2.4482...	-1.024...	13.787...	-	medu >= '4.0'
4	1	190	2.4445...	-0.136...	12.405...	-	freetime <= '3.0'
5	1	225	2.3332...	0.5949...	11.479...	-	Medu <= '3.0'
6	1	116	2.2745...	0.349...	12.52	-	famsup = '0'
7	1	60	2.2430...	0.013...	13.541...	-	Fedu = '1'
8	1				11.460...	-	
9	1				14.538...	-	
10	1				11.653...	-	

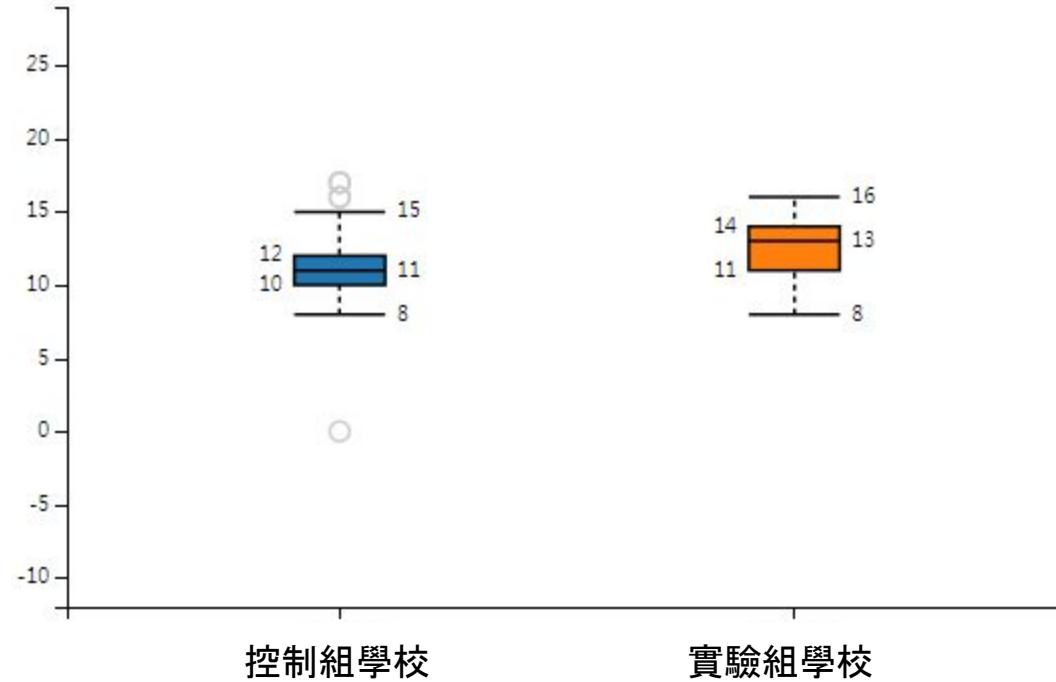
注意斜率正負

規則：自由時間會有影響

Show Model Browse Selected Delete Selected Gaussian p-Values

Close

僅選出freetime ≥ 4 的子群組



實驗組學校(school-2): 47位學生, 平均成績12.5106

控制組學校(school-1): 76位學生, 平均成績11.25

t值-2.98, p值0.0034, 差異達到顯著

分析技術就這樣了
案例整理還有待處理
報告完畢

