# CS.760

Case-Based Reasoning 6

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## Contents

- Testing & evaluation
  - Leave one out
  - Leave one in
  - Global system metrics
- Case competence
  - The Competence Issue
  - A Competence Model for CBR
  - Case Discovery – competence holes
  - Discussion

## Testing

- Testing an ML algorithm is easy (boring but easy)
  - Obtain a data set
  - Divide into training & test data
  - Train your classifier
  - Run the classifier on the test set
- Not so straightforward with CBR

## Testing

- What are we testing?
- The retrieval (classification) accuracy?
  - Then ML methodology is appropriate
- The adaptation accuracy?
  - Validate the accuracy of the generated solution
- The combined accuracy (retrieval & adaptation)
- What about efficiency, speed?
- Also a case-base changes with time….



## Testing

- The performance of a CBR system is the product of a combination of processes
- To test one in isolation may give spurious results
- Difficult to scientifically test all together
- But there are some useful simple tests



## Testing

- Leave one out testing
  - For $i$ = 1 to $n$ (where $n$ = No. cases)
  - Remove $case_i$ and use as a query case
- Useful for finding outlying cases
- Useful for finding dense areas of the case-base

## Testing

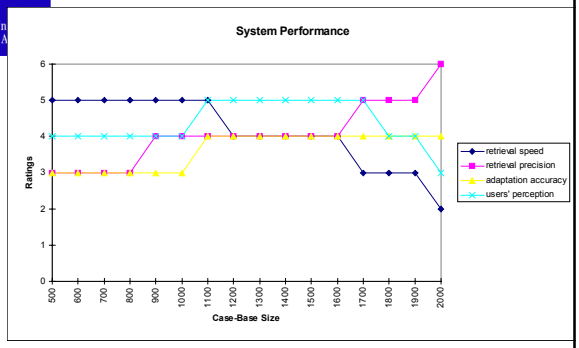
- Leave one in testing
  - For $i$ = 1 to $n$ (where $n$ = No. cases)
  - Do NOT Remove $case_i$ but use as a query case
- query-case should exactly match $case_i$
- Also useful for finding outlying cases
- Also useful for finding dense areas of the case-base



## Testing

- Global system tests
  - Considers accuracy as well as performance issues
  - Since a case-base changes with time
  - Create a reference set of cases
  - Log performance data using this reference set over time
  - Useful way of monitoring relative performance





## Testing

- No point in testing if you know you have a "bad"case-base
- The best retrieval and adaptation algorithms will not work well on a "bad" case base
- But what is a bad or a good case-base?



## Characterizing a case-base

- Motherhood statements…..
  - The case-base should be "representative"
  - The cases should be "well" distributed
  - Cases should be useful
- Doesn't really help us much
- Hence case competence models
  - University College Dublin (Barry Smyth)



## What is performance

- Performance = Competence + Efficiency
- In pure CBR
  - Cases contribute to *both* competence and efficiency

## Recent Developments in CBR

- Real-World Applications
  - Large Scale Case-Bases
  - On-Line Learning
- Emerging Issues
  - The Utility Problem
    - More cases decreases the utility of individual cases
  - Case-Base Maintenance & Case Quality Issues
  - Authoring & Learning Support



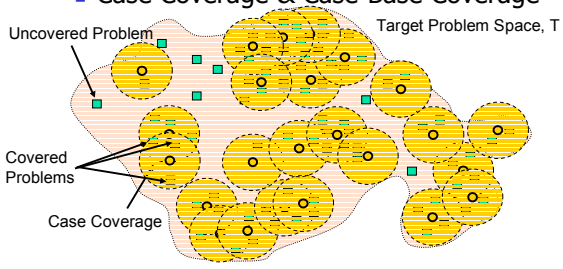
## Open Questions

- Quality Issues
  - Good *vs* Bad Cases / Useful *vs* Redundant Cases
- Controlling Case-Base Growth
  - Building & Maintaining Quality Case-Bases
- Authoring Tools
  - Case-Based Visualization
  - Authoring Guidance
  - Case Discovery – competence holes



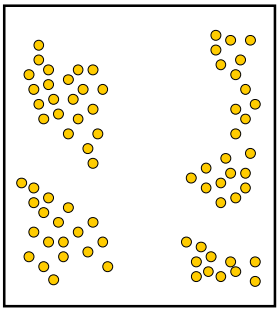
## Case Competence: The Basics

- Case Coverage & Case-Base Coverage



## Mapping Case Competence

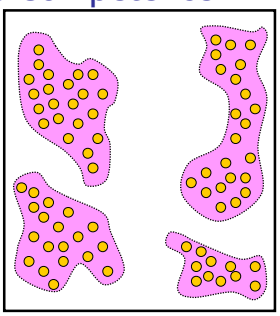
- The Top-Level
  - Problem Space
  - Cases & Target Problems
- Case Coverage
  - Competence vs Efficiency
  - The Utility Problem





## Mapping Case Competence

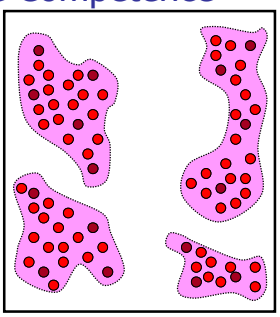
- Competence Groups
  - Independent regions of related competence
  - The fundamental unit of competence





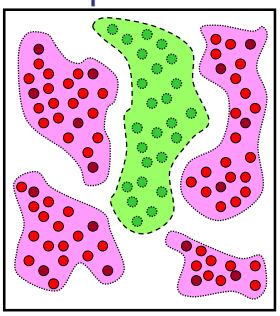
## Mapping Case Competence

- Case Competence
  - Competence categories
- Footprint Cases
  - Cases that provide equivalent coverage to the group as a whole
- Non-Footprint Cases
  - Redundant?



## Mapping Case Competence

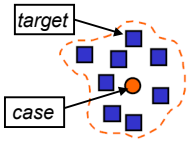
- Competence Holes
  - Uncovered regions and problems



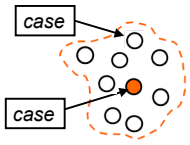


The ***coverage set*** of a ***case*** *is the set of* ***target*** *problems that it can solve.*

coverageset( ● ) = { ■ 's }




*... or, by the representativeness assumption ...*
*(ie we assume the case-base is representative)*




The ***coverage set*** of a ***case*** *is the set of* ***cases*** *that it can solve.*

coverageset( ● ) = { ○ 's }

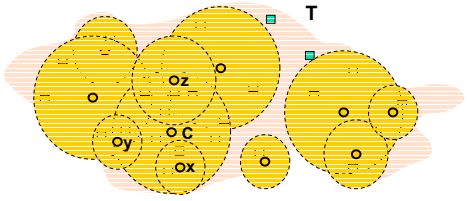


## Case-Competence: The Basics

- An *Ideal* Measure of Case Coverage
  - For a case-base CB and a target problem set T
  - Coverage(c)={t∈T : Solves(c,t)}
- A *Practical* Measure of Case Coverage
  - CB is a representative sample of T
  - Coverage(c)={c' ∈ CB : Solves(c,c')}

## Case Competence: The Basics

- Approximating Coverage Sets




CoverageSet(c) = { x, y, z }



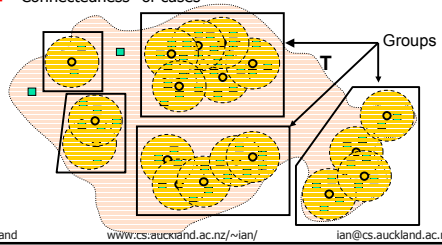
## Case Competence: The Basics

- Case-Base Coverage
  - How does the coverage of the case-base depend on the coverage of its cases?
  - Unique & Redundant Coverage



## A Competence Model

- Competence Groups
  - Maximal clusters of cases exhibiting shared coverage.
  - "Connectedness" of cases



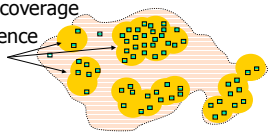
## A Competence Model

- Computing Competence Groups
  - $c_1$ & $c_2$ share coverage iff their case competence overlap
  - $c_1$ $c_2$ & $c_3$ are a Competence Group iff they share coverage



## A Competence Model

- The Importance of Competence Groups
  - Independent regions of coverage
  - ⇒ Independent competence contributions

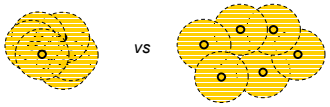


- Fundamental Unit of Competence ?



## A Competence Model

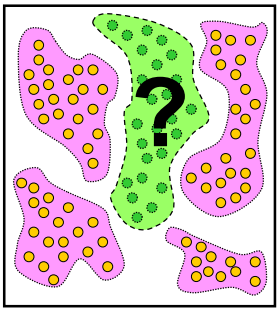
- Group Coverage - The Basic Idea
  - Case Density ∝ Coverage Redundancy $\propto^{-1}$ Group Coverage




  - Regularity Assumption - Similar Problems ⇒ Similar Solutions

## What is a Competence Hole?

- What is a competence hole?
  - Any uncovered region of the target space
- What makes a competence hole *interesting* ?
  - Size of the hole
  - Relevance to target problems



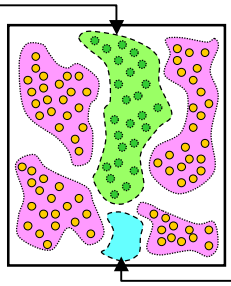



## Two Types of Competence Holes

**Type 1**

Insufficient cases within the case-base.

*Lost coverage.*



**Type 2**

Due to domain constraints – impossible value combinations.

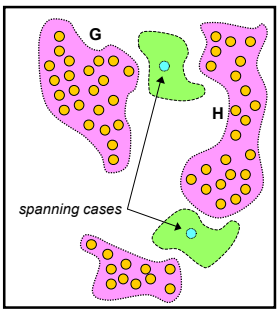
*No lost coverage*



## Identifying Interesting Holes

- Methodology
  - Competence groups that are close to each other may ultimately merge into a single group
  - The missing cases are competence rich ***spanning cases***

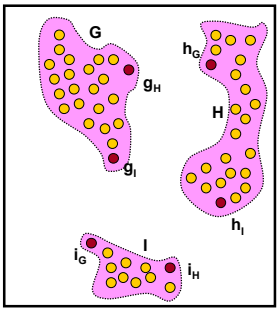
∴ Search for new spanning cases in the regions between nearby competence groups



## Identifying Interesting Holes

- Boundary Cases
  - Each pair of groups **G**, **H** has a corresponding pair of boundary cases, $\mathbf{g_H}$, $\mathbf{h_G}$ (● ) with maximal similarity

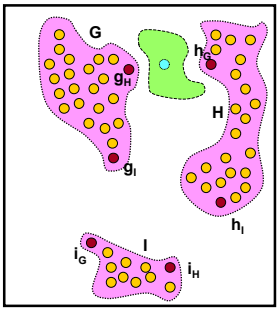
∴ Each group has a set of n-1 boundary cases corresponding to the n-1 other groups in the case-base






## Identifying Interesting Holes

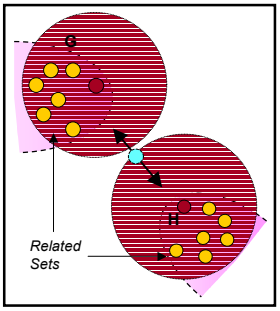
- Interesting Holes
  - For each group we can search for new spanning cases between it and its nearest neighbour group.






## Case Generation (Boundary Method)

- Methodology
  - Generate a new case from the feature values of the related sets of the boundary pair cases
- Nominal Features
  - Most frequent value
- Continuous Features
  - Mean value



## Discussion

- Applications
  - Authoring & Maintenance
- Related Work
  - Competence Categories (Smyth & Keane, IJCAI 1995)
- Assumptions & Applicability
  - Representational Biases

## Case Authoring

- Current Tools
  - Poor modelling & visualisation techniques
- Authoring Guidance
  - Identification of redundant cases and inefficient groups of cases
  - Identification of regions of poor competence
  - Predictive measures of competence and performance

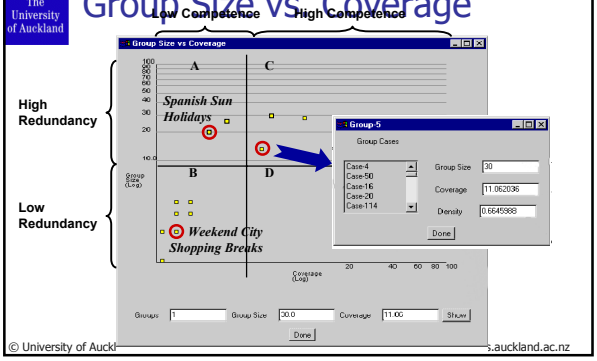
 

## CASCADE

- Case Authoring Support & Development Environment
  - Traditional Authoring Functionality (defining & editing cases)
- Visualisation & Modelling Tools
  - Competence Groups (coverage & density analysis)
  - Competence Graphs

## Group Size vs. Coverage



## Related Work

- Competence Categories (*Explanatory Model*)
  - Pivotal, Spanning, Support, Auxiliary Cases
  - Coarse Grained Competence Patterns
- Current Model (*Predictive Model*)
  - Fine Grained Competence Measures
  - Above categories are found within competence groups. Eg, singleton competence groups hold pivotal cases.

## Assumptions

- Representativeness
  - Case-base is a representative sample of the target problem space ⇒ tractable coverage estimates.
- Regularity & Uniformity
  - Density models assume that regions of the problem space are regular and uniform.
- Real World Case-Bases
  - If these assumptions do not hold then the quality of our competence predictions will degrade (gracefully ?).


# Conclusions

- A Competence Model for CBR
  - Positive initial results
- Future Work
  - Further experiments
  - Authoring & maintenance applications
  - Visualising case-bases

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