Artificial Intelligence

Topics in Artificial Intelligence

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Topics in Artificial Intelligence

Part I : Inductive Logic Programming
Part II: Natural Language Generation

Inductive Logic Programming

- Inductive = Scientific Induction, not Mathematical
  - derivation of new theories/hypotheses/explanations
  - ILP is therefore part of Machine Learning
- ILP provides new hypotheses to explain facts
  - unusual in being based on logic programming
    - compare e.g. neural net based approaches
- ILP used in e.g. scientific knowledge discovery
  - drug design, protein structure prediction

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Logic Programming in 1 Slide

- Language Prolog successful in AI
- Based on (limited) reasoning in First Order Logic
  - p(X) *if* q(X), r(X).
  - q(a).
  - q(b).
  - r(b).
- X is a variable, a, b constants
- p(a) is false, but p(b) is true
- Prolog automates the finding of solution p(b)

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Formal Setting for ILP

- Use a family of logic programs
  - Background knowledge ***B***
  - positive examples E+
  - negative examples E-
  - Must construct hypothesis H
- Require some formal properties
  - Necessity: B =/=> E+
  - Sufficiency: B & H => E+
  - Consistency of B & H
  - Strong Consistency: B & H & E- consistent
  - (can disregard last two in a “noisy” system)

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How to derive Hypotheses

- Remember sufficiency: B & H => E+
- We can reverse this using logical contrapositive
  - B & not(E+) => not(H)
- The two statements of negation are equivalent
  - but the second allows hypothesis to be deduced
  - using logic programming
- Special algorithms allow deduction of various H
- Built into ILP systems such as Progol, Golem, …

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Scientific Knowledge Discovery

- ILP has been used in biology
  - e.g. most successful automated system in National Toxicology Program test on carcinogenicity
- E.g. Discovery of protein structure
  - Background B defines molecular dynamics
  - Examples E+ have certain structure
  - Examples E- do not have structure
  - Construct hypothesis H to explain E in terms of B
  - e.g. “4-helical-up-and-down-bundle”

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ILP Prediction

- Fold(‘4-helical-up-and-down-bundle’, P)
- ***if***
- helix(P,H1),
- length(H1,hi),
- position(P,H1,Pos)
- interval(1 <= Pos <= 3)
- adjacent(P,H1,H2),
- helix(P,H2)

- Protein P has class “4-helical-up-and-down-bundle”
- if
- it contains a long helix H1
- at a secondary structure position between 1 and 3
- and H1 is followed by a second helix H2

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Natural Language Generation

- Natural Language Processing
  - usually used for understanding/using text written by people
- Natural Language Generation
  - much less widely used
  - computer writing human readable text
  - e.g. you’ve done it in Turing test programs!
  - You’ve see limits to general conversation
    - but can be useful in specific domains with lots of detail
    - and get to interest Royalty

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Intelligent Labelling Explorer

- ILEX
  - Prototype interactive system
  - Edinburgh University, ‘95-98
- Labels:
  - Descriptions of objects in museum
  - currently virtual museum
- Intelligent?
  - Take account of user
    - tailor information given to objects viewer has already seen
- Demo available on-line

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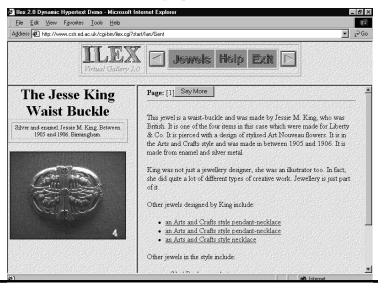
In case the demo is flaky (1)



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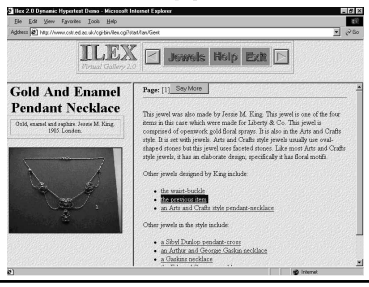
In case the demo fails (2)



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How ILEX works

- Pictures, links etc conventional Hypertext
- Museum "labels" generated on-line as necessary
  - labels tailored to individual users
    - specifically, what they have seen and been told
- Text generated in 4 stages
  - Content selection
  - Content structuring
  - Sentence realisation
  - Text presentation

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Content Selection

- Knowledge base of facts
  - details about objects in gallery, artists, styles, etc.
  - obtained from NL processing of database
    - and interviews with staff
- Knowledge base?
  - Knowledge structured formally inside computer
    - e.g. set of first order logic facts or Prolog program
- ILEX uses specialist knowledge formalism
  - main data structure called "text potential"
    - graph containing nodes representing objects, facts, and relations between facts
    - facts to be told selected by graph traversal

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Content Structuring

- Build Discourse Structure for expressing chosen facts
- Discourse structure is two level
  - high level "entity chains",
  - low level "rhetorical structure"
- Entity chains
  - A collection of facts about the same entity
  - Initially, collection of facts about the selected object
    - facts can mention other objects added to the chain
- Rhetorical Structure
  - built on relations like "exemplification", "specification", etc
  - add RS trees to entity chain until no more can be added

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Sentence Realisation

- Modules used to decide surface form of expressions
- **Fact expression** module
  - tense, mood, etc of a clause expressing a given fact
- **RS tree realisation** module
  - determines expression the relations between facts in a RS tree
    - using sentence and clause conjunctions.
- **Aggregation** module
  - determines when facts can be aggregated into a single sentence
- **Noun Phrase planning** module,
  - chooses full descriptions, reduced descriptions, or pronouns

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Text Presentation

- Everything decided so far put into text and presented to user
- Interactive dialogue shows some of the processes
  - e.g. in first page in this presentation
    - discourse seen in two paragraph selection of text
    - use of pronouns … "It is.."
  - in second page, "this jewel was also made by…"

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Summary

- Two fairly new fields of AI
  - Inductive Logic Programming
  - Natural Language Generation
- Both extending existing field
  - Logic Programming & Machine Learning
  - Natural Language Processing
- Both fielded new applications
  - biological activity prediction
  - museum label generation

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