Semantic Relation Analysis and Its Application in Cognitive Profiling

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Motivation

■ What is cognitive profiling?
Process of detecting the cognitive abilities of learners such as
- Working memory capacity
- Inductive reasoning ability
- Associative learning skills
- ...

■ Why do we need cognitive profiling?
- Avoid cognitive overload for learners
- Using information about learners for adapting courses with respect to the learners’ cognitive abilities
How to get information about the learners?

Student Modelling

- Collaborative Student Modelling Approach
- Automatic Student Modelling Approach

Content-less Navigational Pattern Analysis

Content-based Navigational Pattern Analysis
Content-less navigational pattern analysis

- Every webpage is treated as a node
- Every webpage is treated equally regardless of its content
- Relationships between the nodes are not defined
- Focus is on the navigational behaviour (certain navigation patterns indicate navigation approaches such as searching or browsing)
- Domain-independence
  - Reusable across different domains
  - Inaccurate in specific situations
Content-based navigation pattern analysis

- Primary analysis method for most of the performance-based student models, recording students’ progresses and grades
- Contextualised semantic information of every node is recorded (based on domain ontology or concept map)
- Learning system makes inferences about the learners and stores the information in the student model
- Benefit: Accurate due to semantic information
- Drawback: Domain-dependence
  - For a new domain, similar effort of analysis have to be carried out
  - For modifications in the domain ontology, inferences rules have to be re-written
Semantic Relation Analysis (SRA)

- Based on the idea of Semantic Web
- Uses semantic information about relationships between learning objects
- Two learning objects can be related to each other in different ways
- Learning Object Metadata (LOM) already defines 12 different types:
  - IsPartOf, HasPart
  - IsBasedOn, IsBasisFor
  - Requires, IsRequiredBy
  - References, IsReferencedBy
  - IsVersionOf, HasVersion
  - IsFormatOf, HasFormat
- Is extended by Vijver et al. (2002) by the types HasExample, ExcursionTo, and Evaluates
- Through categorising of relationships, SRA is domain independent but contains semantic information
Semantic Relation Analysis is applied in the Cognitive Trait Model (CTM) to discover information about the learners’ cognitive traits.
Empirical Study with respect to Inductive Reasoning Ability

- Participants: 29 students from Massey University, New Zealand (studying in Information Systems course)
- Participants used a learning system that tracked their behaviour
  - Read the descriptions of the concepts
  - Take a quiz consisting of multiple-choice questions
- Participants were asked to perform a web-based inductive reasoning test (Web-IRA)
  - Consists of 30 questions, including 3 types of tasks (series extrapolation, analogical reasoning and exclusion)
  - Questions are presented in a sequential order and must be solved in this order
  - Online accessible
  - Time mechanism is built for detecting abnormalities
Analysis and Results

- The number of correct answered questions in Web-IRA was used as index of inductive reasoning ability.
- Inductive reasoning ability was also calculated through the cognitive trait model based on semantic relation analysis.
- The conducted rank correlation analysis showed a significantly correlation between the results of both approaches ($\rho=0.382$, $p=0.02$).
- Results supports the use of SRA in cognitive profiling.
Conclusion

- Introduced a novel approach called Semantic Relation Analysis, which combines the strengths of content-less and content-based navigational pattern analysis by using semantic information about relationships between learning objects.
- Demonstrated exemplary application of the Semantic Relation Analysis for identifying inductive reasoning ability.
- The result of the empirical study showed a significant correlation between the automatic student modelling approach by semantic relation analysis and the collaborative student modelling approach by using Web-IRA.
- This result supports the proposed approach of using SRA for cognitive profiling.
- Future work:
  - Identifying more new potential application areas of SRA.
  - Exploring how it can be integrated into the tracking service of SCORM in order to provide easy integration mechanism for learning system developers.