Investigating Educational Attractors and Life Tracks in e-Learning Environments Using Formal Concept Analysis

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Motivation

- online educational platforms are an important part of the education system;
- discover user behavioral patterns in e-learning environments;
- understanding how the presentation of the learning content and the overall structure of the e-lesson is used.
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overview

- the Formal Context (def)
- the Context as cross-table representation (ex)
- the Formal Concept (def)
- all resulting Formal Concepts (ex)
- the Concept Latice (ex)
the Formal Context

Definition
Formal Context: triple $K = (G, M, I)$ with
- set $G$ of objects
- set $M$ of attributes
- incidence relation $I \subseteq G \times M$
the Context as cross-table representation

<table>
<thead>
<tr>
<th>Planet</th>
<th>Size</th>
<th>Distance to Sun</th>
<th>Moon(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>small</td>
<td>near</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>medium</td>
<td>far</td>
<td>no</td>
</tr>
<tr>
<td>Jupiter</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Mars</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Mercury</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Neptune</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Pluto</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Saturn</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Earth</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Uranus</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Venus</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
the Formal Concept

Definition

Formal Concept: pair \((A, B)\) with
- extent \(A \subseteq G\)
- intent \(B \subseteq M\)
- \(A \times B \subseteq I\)
- maximal w.r.t. this property
all resulting Formal Concepts

The planet context has the following concepts:

- $(\emptyset; \{\text{Near; Far ; Small ; Medium; Large; yes; no}\})$
- $(\{\text{Jupiter; Saturn}\}; \{\text{Large; Far ; yes}\})$
- $(\{\text{Uranus; Neptun}\}; \{\text{Medium; Far ; yes}\})$
- $(\{\text{Earth; Mars}\}; \{\text{yes; Near; Small}\})$
- $(\{\text{Mercury; Venus}\}; \{\text{no; Near; Small}\})$
- $(\{\text{Jupiter; Saturn; Uranus; Neptun}\}; \{\text{Far ; yes}\})$
- $(\{\text{Earth; Mars; Mercury; Venus}\}; \{\text{Near; Small}\})$
- $(\{\text{Jupiter; Saturn; Uranus; Neptun; Earth; Mars}\}; \{\text{yes}\})$
- $(\{\text{Mercury; Venus; Earth; Mars; Jupiter; Saturn; Uranus; Neptune}\}; \emptyset)$
the Concept Latice
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Attractors

*attractor* = behavioral patterns to which users adhere while using the educational/e-learning system

state what should users do and then evaluate if they adhered to these views or they have found their own ways to use the system
Educational attractors

The structure of an educational attractor reflects the intended educational purpose of the e-learning platform.

We can investigate if web usage behavioral patterns are fitting into the educational scopes of the instructor or there is place for improvement.
Educational attractors

Example on Lab Theory per weeks:

- LT1, LT2, ....
- The structure of the educational attractor is displayed as an order diagram of the underlying concept set as it has been determined from the web-logs dataset by using FCA.
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Comprehensive behavior

User behavior of student C on week 3

Lab Theory first 6 weeks
Comprehensive behavior

User behavior of student E on week 3

Lab Theory first 6 weeks
Comprehensive behavior students

• *Early birds* are students that have accessed the provided material before it was expected;

• *Common users* are students that behave as expected;

• *Late rise users* are students that visit the provided material later than expected.
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Distill user life tracks using Temporal Concept Analysis

Life tracks are built by setting time granularity at week level and marking the temporal trajectory of the student through the educational attractor Lab Theory or Lab Assignment.
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Life tracks

Early bird
student C

left-shifted behav.

downward placed nodes

on visiting Lab Theory per weeks
Life tracks

Common user

student D

on visiting Lab Theory per weeks
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Correlate comprehensive behavior with academic performance

- **Early birds** (e.g. H, D, K) got the mark FB (very good);

- **Common users** (e.g. I) got the mark B (good);

- **Late rise users** (e.g. S, T) got the mark I (insufficient).

- exception **early bird C**
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Handing assignments behavior

- Before deadline: 36.45%
- At deadline: 19.97%
- After deadline: 18.01%
- Unhanded: 6.53%
Life tracks on handing assignments

Early bird
student C
Life tracks on handing assignments

Common user
student K

before deadline  at deadline  after deadline  unhanded

at assignment

L3, L5, L11
L7, L10
L4, L6

before assignment
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Life tracks on educational attractors

For each assignment students are expected to:

• first read the assignment,

• then to consult the laboratory support (i.e.,
  • the theory and
  • example) and

• then to check other related material (e.g.,
  • lecture notes and the
  • explanations on the test papers).
Educational attractors

Example for the concept presented on week 9:

- Lecture 7
- Lab Theory 9
- Example 9
- Lab Assignment 9
- Test Paper 9
Educational attractors
Educational attractors
Educational attractor correlated with final marks
Life tracks on educational attractor of Lab 9

Early bird

student C
Life tracks on educational attractor of Lab 9

Common user

student D
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Conclusions

• we defined student behavioral pattern, called comprehensive behavior

• we used Temporal Concept Analysis to investigate how users adhere to educational attractors and we observed that:
  • early birds and common users adhere to the educational attractor
  • late rise users access only the assignment page and maybe one more
Future work

• detection of similar behavior using FCA similarity measures

• advanced pattern detection using relational FCA and pattern structures
Questions?
Thank you for your attention!