The Temposcope: a Computer Instrument for the Idealist Timetabler

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Overview

Orientation on computing and computer-aided timetabling.

The particular timetabling case study as illustration of the approach (Empirical Modelling) being adopted.

Principles, tools and methods of Empirical Modelling

Introduction

TT is one of many activities (decision support, design, learning, etc) where full automation is neither possible nor desirable.

But in semi-automatic systems the advantages of automation are often gained at expense of advantages of human intervention.

This need not be so.

Objective here is to introduce principles to promote much greater human computer integration, illustrated by an instrument that supports cognitive models of the human timetabler as well as state representations suited for automatic processes.

Humans or Computers

The human approach to a timetabling task involves some mental model of the events and participants, it is imprecise, exploratory, qualitative, informed by experience, intelligent, considered in a context and from a perspective. Human methods for the task will involve lists, tables, diagrams, etc and are opportunistic and highly adaptable.

Computers are fast, accurate, comprehensive, consistent and uniform, reliable at recording and retrieving, good at algorithms and data management. Computing methods of programming, or application building, often use abstractions that are alien to the user's world. Mental models of the programmer and the user are usually very different.

Humans and Computers

To integrate human and computer activity closely requires ways of representing state which are both comprehensible to humans and amenable to automatic processing.
It is desirable that human users can invoke, suspend, monitor, intervene in, any activities that are delegated to the computer.
Suggest that problems with integration are due to programming paradigms that describe the application in terms of 'problems' suited for algorithmic solution (by circumscribing the application).

Aim here to show how we can give automated support to modelling situations without such circumscribing by building artefacts that remain open to arbitrary interaction.

Computing for the Idealist

The idealist typically explores, experiments, seeks to understand, use imagination and intelligence to adapt. The focus of the idealist is on situations rather than pre-defined processes.
We call our computer artefacts, *interactive situation models* (ISM). Construction of ISM shaped by actual situations not abstract i/o processes (cf conventional programming).

Precedents for this paradigm occur in relational databases and spreadsheets but adopting the concepts of observables, dependency, agency as fundamental for representing state and state change in general is new. Using these concepts make ISMs unusually flexible and allow conflation of views of user and developer. Definitions embody domain knowledge and facilitate experiments to test relationships between observables.

Realists versus Idealists

Two aspects of semi-automated activity are

(i) interactive algorithms with pre-conceived input;
(ii) unpredictable input informed by human intelligence.

Usually need both aspects, but the emphasis reflects the perspectives of:

pragmatist versus the perfectionist
realist versus the idealist
administrator versus academic

Computer support for the realist is familiar – our approach is motivated by aiming to support the idealist as well.

Computation and Experience

Spreadsheet: state change through dependency and agency
Broadening of notions of computer and programming

Construe phenomena by observables, dependency, agency
Perceptions based on modeller's viewpoint + interpretation
Allows subjective, provisional, description on computer
Like an artist's early sketch v. an architect's final drawing

Experiment and observation are fundamental, hence 'EM'.

A Timetabling Task

Project oral examinations for final year students.

Each student (of 120) assigned three staff and allocated to a 30 minute time slot in a 5-day period. Initial constraints are availability and suitability of staff, and balanced work-loads.

Further qualitative issues include fragmentation of staff attendance, distance factors, subject themes, balance of experience and convenience.

Significance of scale.

Concept of the Temposcope

Perspective of an instrument – offering support for extending, recording, surveying relevant observables.

Distinctive role (compared with a tool) with regard to function, interface, user/developer roles, efficiency/cognition.

Instrument is intertwined with emerging artefact (timetable); three roles can be distinguished: *designer* (appropriate dependencies and kinds of observables), *technician* (appropriate data for particular situation), *user* (range of interfaces and effective ways to use instrument).

Construction of the Temposcope

Structure of:
- availability of staff (ABC_AV, ...);
- assignment of staff to students (SAM);
- allocation of students to slots (TT).

Many relevant observables are related by functional dependency; formulating such dependencies is a major part of the (manual) construction. Groups of dependencies form simple mechanisms corresponding to components of the timetabling task as they arise in the human timetabler's mind. Example.
This style of construction crucial to preserving openness, and validation through experiment, of the artefact that results.

Temposcope definitions (1)

```
staff is ["ABC", "OBJ", "PVC", ..., "GLC", ....]
/* list of staff */
SAM is [["James Bond", "ABC, "PVC", "GLC"],.....]
/* supervisor, assessor, moderator assignment */

TT is [["James Bond",3], ...]
/* partial timetable - list  of (student name, scheduled slot) */

ABC_AV is [1,3,4,6,8,....]
/* list of slots that ABC has declared as available */

avail is [ABC_AV, OBJ_AV, PVC_AV, ..... GLC_AV, ...]
/* declared availability of staff members */
```

Temposcope definitions (2)

```
assign is makestaffassign(TT, SAM);
/* slots so far assigned to staff members */

current_student is "James Bond";
/* student who is currently the focus of interest  */

S is
index(staff,supervisor(current_student,SAM));
A is index(staff,assessor(current_student,SAM));
M is index(staff,moderator(curent_student,SAM));
/* S is identifying index for supervisor of current student ..*/

avSAM is MEET(avail[S]-assign[S], avail[A]-assign[A], ....);
/* possible slots in which to schedule current student */
```

HCIntegration in the Temposcope

Manual progress can be made by assigning current_student, then assessor and moderator, then allocating to an available slot. Invoke automatic checks for consistency and load balance.

Could automate by iterating through students from those with fewest available slots. When problems arise invoke modeller's knowledge of the availability of staff (for example) for increased flexibility to experiment manually.

Finally deal with room allocation – generally automatically, but with manual intervention on designated students.

Empirical Modelling

A novel approach to *computing* which is

- experience-based because *state-as-experienced* is basic;
- human-centred because key concepts of *observables*, *dependency* and *agency* are central to human sense-making and cognition;
- a generalisation of spreadsheets in respect of interface, data types and many users;
- adopting a computational paradigm of state change through dependency and agency as fundamental.

Human Computing

A motivation for the approach is to bring closer together the human treatment of observables with computer treatment of data: could call this 'human computing'.

Initial perceptions of a domain are organised into an account that groups observations into agents and classifies observables according to their role in agent action.

Dependencies recorded in definitions relating observables. States correspond to scripts of definitions and their visualisation, state-change occurs in the act of re-definition.

Agents have privileges for action, modeller is super-agent.

Tools for ISMs

Tools for model construction: EDEN supports

- definitions with dependency maintenance
- user-defined functions
- actions (groups of re-definitions)
- notations for visualisation and animation
- distributed operation, variety of communication modes
- versions for UNIX and PC platforms

Realist	Idealist
Uses abstract state and data representations	personal and situated data
follows hidden algorithm	under control of timetabler
specifies intended use	open-ended environment
hard to adapt for unforeseen uses	highly flexible (for expert modeller!)

ISMs and Cognitive Artefacts

Methods allow rich state-transition models that remain open to arbitrary interaction in development.

Scripts represent modeller's context and viewpoint – the models have a *situated* quality. Hence term *interactive situation models* (ISM).

Actions and observables are at human cognitive level and so well-suited to end-user development.

Computer-generated experiences are a mode of knowledge representation – mediated by metaphor and interaction. EM models well-suited to this style, hence *cognitive artefacts*.

Realist	Idealist
scalable for large problems	relies on distributed work
batch style interaction	spreadsheet style working
easy to use with 'given' interface	interface built interactively
high quality input	arbitrary input, revisable
i/o interpreted by preconceived conventions	interpreted by modeller according to situation
computer is abstract device with formal semantics	computer is artefact

Conclusion

Shift of perspective on computation using observables, dependency and agency is fundamental rather than cosmetic, affecting analysis, interface design, visualisation and data management.

The Temposcope, while simple, realises potentially far-reaching principles for semi-automated activity. For example, could readily be extended to include assessment profiles for students and staff, and could include presentation materials and project source materials for later analysis and reference.

Important future research work relates to effective and flexible interface design for a variety of users and contexts.