Agent-oriented Modelling
and the
Explanation of Behaviour

Empirical Modelling and the Explanation of Behaviour

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Content

Three objectives for talk

1. **explain / explore significance of our modelling method**
2. distinguish from other approaches
3. indicate why relevant to other themes of workshop

1. Significance of the modelling method

- develop models of system behaviour to integrate
  circumscribed behaviour + immediate experience
  conventional programmed processes + autonomous actions
- appropriate framework for representing agents, views, states
- supplies new representation for system decomposition
  empirical modelling

2. Distinguish from other approaches

Unlike conventional formal / pragmatic approaches

- "principled" but not formal?
  draws on extralogical intuitions (e.g. identity, reference)
  cf process by which we use a spreadsheet
  ... *"anti-abstraction" stance*
- not OOD/OOP: focus on observations not objects
  object ≡ particular kind of behaviour
  subjectivity of behaviours ⇒ subjectivity of objects

In spirit similar to SIMULA:
principles of programming should stem from real-world modelling

3. Relevance to themes of the workshop

- "interactivity" of Chmilar-Wyvill$_B$ design+animation
- virtual reality:
  constructing deep models to underlie visual displays
- supply framework for specifying complex modelling systems:
  dealing with reference to objects
  expressing user interaction
    e.g. in making aesthetic judgements
  conceiving more sophisticated implementations
- design applications

The System Decomposition problem

How to relate the behaviour of a system to the activity of its constituents?

problem at the heart of programming

requirement = behaviour of a system
program = activity of its components

also relevant to VR, where user is an embedded constituent and have to simulate direct intervention of user in system

Generalised Programming

Adopt very general perspective on system and programming

human, engineering, software components

human (e.g. railway protocol, game of cricket)
engineering (e.g. vehicle cruise controller)
software (e.g. parallel programming, interface specification)

programming prescribing the behaviour of all kinds of agents

... need for making a VR model, constructing a **reactive system**

Real world modelling ↔ Virtual Reality

What considerations limit scope for realistic simulation? e.g.

on what basis is a simulation to be trusted?

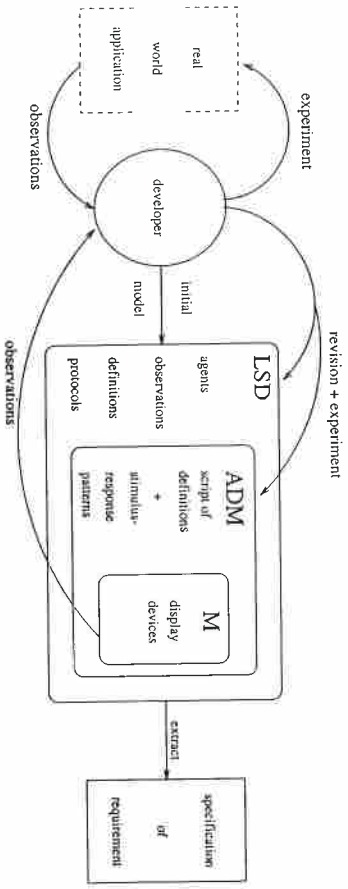
what possible limitations on development of VR models?

of what relevance is explanation of system behaviour?

Our **Empirical Modelling** process ...

whilst model is improving {
  by correlating
  experience of the world and experience of the model
    identify observables: things perceptible by agents
      " indivisible relationships
      " agents
      " stimulus-response patterns and constraints
    refine context for experience
  /* have a m-agent system, where m≥1 */
  /* includes the modeller as agent */
}
derive specification via an act-of-faith
/* commitment eliminates the modeller as agent */
/* specification is a 0-agent model */

experience = observation (passive) + experiment (active)



Empiricism

Common element in every step of the identification process

Affirm the integrity of an entity from repeated experience
e.g. same wife in bed every morning, but not same clouds in sky

Affirm indivisible relationships from repeated experience
e.g. caravan follows car down the road,
but not three 68 buses one after the other

Affirm the presence of agents etc. etc.
e.g. I create the pattern of light on the screen,
but you scratch your heads

Affirm presence of stimulus-response patterns and constraints etc.
e.g. you can fall asleep in my talk, but I can't

Empirical modelling ....

Shorter Oxford English Dictionary 1955

empirical

1. Based on, guided by, the results of observation and experiment only. *1569*

3. Guided by mere experience, without knowledge of principles. *1751*

4. Pertaining to, or derived from, experience. *1649*

empiricism:
The theory which regards
experience as the only source of knowledge

empirical

2. That practises physic or surgery without scientific knowledge; quack. *1680*

Observation

behaviour more primitive than object

analyse the concept in terms of observation

observation: "something perceptible by an agent"

requires identity: something whose value changes
cf motion of a cloud vs motion of a car

"thing with identity" as primitive observable

scientific association of the term:
observable in sense of science not directly perceived

BUT behaviour governed by more than this:
perceived by agent ≠ objective observable

agent responds to more sophisticated perceptions of state
e.g. perceptions of history, interpretation

Indivisibility

What belongs to the present context?

- *adding* a definition to a spreadsheet ≡ refining the context
  redefining a variable ≡ refining or changing context

cf sequential programming: inst1, inst2, inst3, ...
only state contexts are between instructions

- present context not as time, but as what we deem it to be
  e.g. scientific measurements *belonging to the same context*

contexts are defined by interaction between agents

e.g. user imagines lift arrives at floor before actual lift does
OK provided the user's idea of where the lift is private

- content relations
  as ball hits court outside baseline, so tennis match is lost

Agents

Distinguish many ways to move the train

allow it to run around the track

move the layout with the train on it

build the track as the train is running

pick up the train

throw the train across the room

hit the train by throwing another object at it

... motion of the train is attributed to an agent, possibly itself

cf OO modelling

Can also represent the modeller(s) as meta-level agent(s)

Commitment and context

Process of commitment may be incremental

Only after commitment can we make universal statements

Only in the 0-agent world can we formulate a logical model

context gets refined as we make commitments

e.g. of course I can fall asleep in my talk

of course everything that happens at an instant

could be attributed to a single action by a superagent

of course it could be somebody else's wife ...

... but context is shaped to suit purpose of model

Circumscribed and autonomous behaviour

Use spreadsheet + metaphors for state as paradigm

for representing system state (ADM)

- can have many strands of parallel redefinition
- 1-agent is sufficient to simulate (parallel) actions of many

modeler simulates experience of the system through intervention in the model

simulates autonomous actions of agents likewise

- can also introduce circumscribed behaviour

e.g. impose actions synchronised with clock / event sequence

Integrating theory into models

Circumscribed behaviour used to embody theory ....

cf **empirical** ...

3. Guided by mere experience, *without knowledge of principles.*

Theory is useful in modelling

e.g. may need to use Newton's 2nd law of motion in model

Benefits of theory similar to those of object abstractions

allow the designer to proceed more efficiently

"we can take these things for granted" (embody an act-of-faith)

cf model execution is faster when exclude possible intervention

re-use of experience

Illustration 1:

Empirical modelling for game simulation

modelling has only a descriptive element

Tennis simulation

players have basic faculties

exercise particular skills

have certain percentage reliability

adopt strategies

... expect to achieve high degree of realism in patterns of play

e.g. dealing with obstructed vision,

context-dependent responses

ball nearly out of play but matchpoint etc.

... expect to be able to attribute patterns of interaction

Matters arising ...

Introduction of agents

circumvents traditional reductionism:

gives a new status to explanation

At some level of abstraction: **we know why**

the specification of tennis players ⇒ the model of tennis

Contentious issues:

- can get "authentic" models for the chosen agents?
- there can be a "principled" approach to modelling if know the agents and the nature of their interaction intimately?
- empirical approach eventually leads us to deny the relevance of further experience (with respect to our modelling aim)

act-of-faith where empiricism renounces an empirical stance

commitment ≡ *experience suggests that I don't need any more experience to affirm that ...*

Formal descriptions of system behaviour

mathematical models

computational abstractions with precise operational semantics

formulate requirement as abstract pattern of behaviour

issues

relating abstract behaviours of components & system

mathematically intractable

cf Langton's ant, Turing halting problem

formal models represent circumscribed behaviours

to use the representations need to preconceive

Alternative to formal approach

NOT

computational abstractions with obscure operational semantics

BUT

computational abstractions that faithfully reflect

our partial knowledge of behaviour

need to be able to represent what we are committed to believing

without compromising the entire description of behaviour

definitive scripts capture local, immediate expectations

object abstractions get in the way of representing the immediacy

NOT

I can pull a lever with these procedural side-effects (when?)

OR

[by pulling a lever] I can initiate all these direct effects (now)

BUT

this is what happens in the context in which I pull this lever*when* I pull this lever, as an inseparable part of this action

Experience informs formal behaviour of system

observe phenomena

identify reliable phenomena

construct components based on reliable phenomena

synthesise groups of components to develop subsystems

constrain the context for interaction between components

establish conventions for human interaction within system

[NB not a sequential process]

... if sufficiently thorough experience, make basis of act-of-faith

can *then* describe behaviour formally

cf experiment → theory in science

development process in engineering

Picture of the modelling process at this point ...

Formal approaches

- detract from the highly subjective nature of behaviour

  hide the experiential content and the act-of-faith

- tend to reinforce idea of abstract ways for transforming

  requirement → system specification

  because have e.g.

  automatic programming techniques for sequential programs

  functional programming

  mathematical modelling

  choice of parameters in differential equation

Principles for prescribing behaviour

- take account of

  what is observed, how its observed, when its observed

  by whom its observed

- acknowledge that there is NO general method of devising system behaviour

  aim at methods of representation that allow us to record experiential knowledge

  enhance models incrementally to reflect commitments

  create environments in which can appreciate how system behaviour is perceived to depend on that of its constituents

NOT this is how the system behaves
BUT
behaviour of the system = function(behaviour of its constituents)