

Empirical Modelling and the Explanation of Behaviour

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Shape Modelling: Parallelism, Interactivity and Applications: AIZU Sept 1994 1 ✓

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

Content

- Objectives
- The System Decomposition Problem
 - relevance for programming and VR applications
- Our *empirical modelling* process
- Observables, indivisibility, agents as empirical concepts
- Commitment and theory
- Significance of the empirical modelling process
 - reductionism and explanation, empiricism and theory
- Formal specification of behaviour
- Empirical programming: the lift example
- Summary and Moral of talk

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

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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-Wyvilg 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 $m \geq 1$ */

/* includes the modeller as agent */

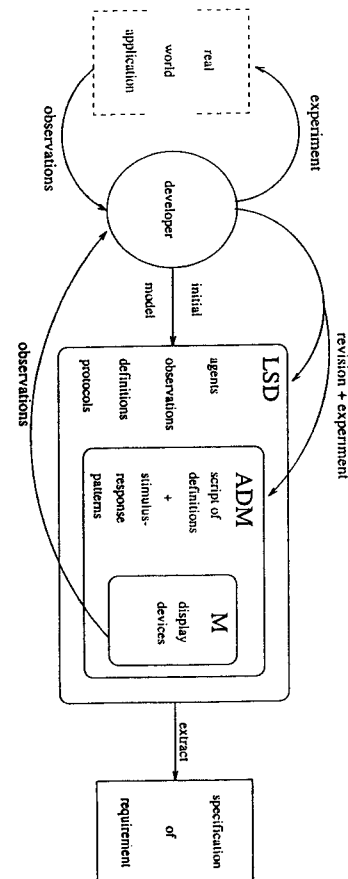
}

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 \neq 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 \equiv refining the context
redefining a variable \equiv 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
of 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 \Rightarrow 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 \equiv *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

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

Picture of the modelling process at this point ...

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)

Illustration 2:

Empirical Programming for a lift system

programming has a descriptive and prescriptive aspect

empirical modelling in parallel

by the user, the analyst and the implementer

concurrent engineering process

Moral of the talk

... there be dragons

... issues for *all* approaches to modelling and programming

- dangerous combination:

formal operational semantics for components

+
formal specification of behaviour

- don't want premature commitment to formal models

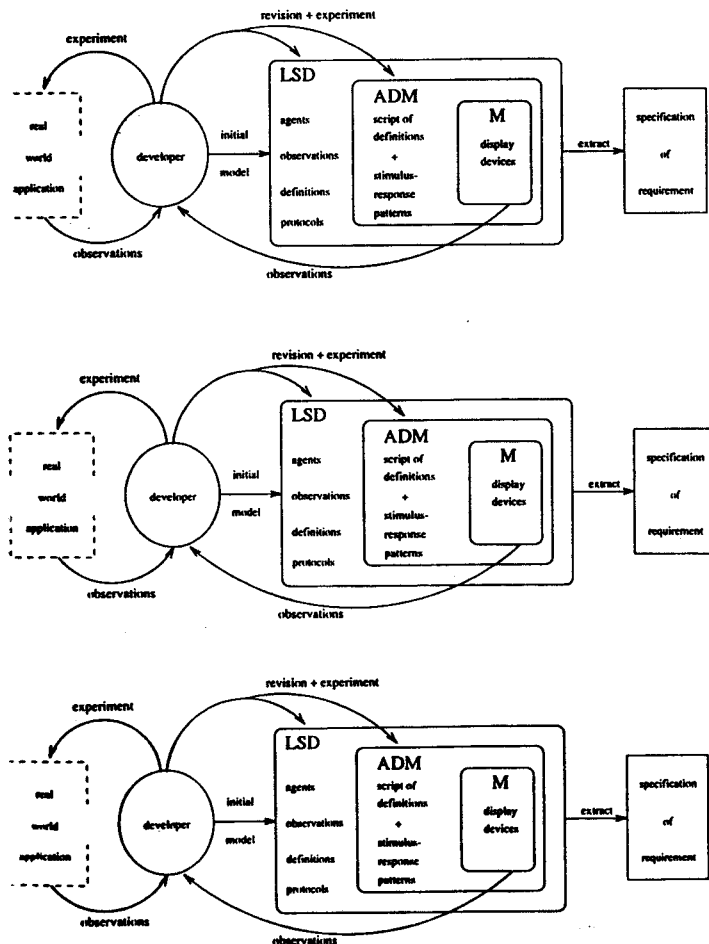
such models don't properly reflect our ignorance of the application of Ficts

(some) theory must be application-specific

- have to develop modelling methods open to experience

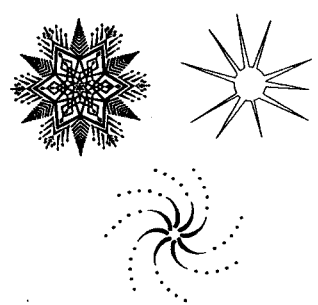
have to understand the relation between our experience and our commitments

need to know how to take account of evolving experimental knowledge of Brooks "grow, not build software"



Ficts are one the oldest forms of life on the planets Alias and Bias.

They are renowned for the extraordinary configurations into which they organise themselves, and have been the subject of scientific study on both planets.



Principle inhabitants of Alias are the A-I: they have a highly intelligent and technologically advanced civilisation.

The inhabitants of Bias are the B-O: a people infamous for their powerful scent who are less advanced in scientific matters, but have a well-developed sense of humour.



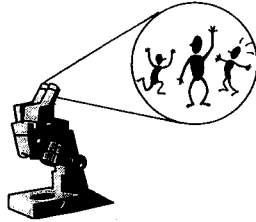
For many centuries on Alias, identifying and interpreting geometric patterns in conficts could only be done by the Alian religious leaders.



Poo, what's that smell? Run away!!

The B-O can see individual ficts directly, but are handicapped experimentally because active conficts are thrown into confusion by B-O presence.

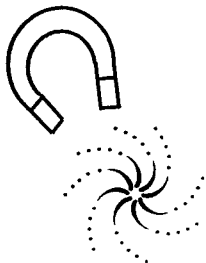
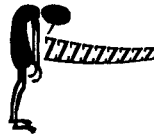
The theory that conficts consisted of colonies of ficts was well established long before the invention of the microscope first made it possible to observe individual ficts.



The B-O were the first to be aware of the correlation between orientation of ficts and their colour. Bodkin tested this by dyeing black ficts red but the experiment failed. There are red varieties on Alias that don't obey this rule.



Microscopic examination showed that there were two kinds of confict: active and quiescent.



Shortly after they discovered magnetism in C20, the A-I observed that quiescent conficts were arranged in orbits that followed the lines of the local magnetic field. The organisation of active conficts at present remains a mystery to the A-I.

My A-I's got no nose

How does it smell?

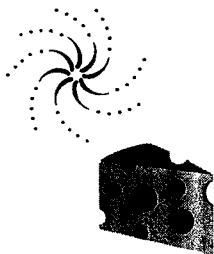


B-Os believe that ficts are intelligent and that active conficts are ritual joke telling ceremonies. A-Is do not believe that ficts are intelligent.



In fact ficts are very intelligent. Alignment and orientation to magnetic field are matters of social convention.

Ficts organise themselves into patterns to leave scent traces that record the location of food sources. These pheronomes are over-powered by B-O presence – a fact inexplicable to the A-I as they have neither experienced nor developed a concept of scent.



My A-I's got no nose

How does it smell?

It can't!!!

