Fits and misfits - comparing systematic dimension models

Chris Roast, Andrew Dearden, Babak Khazaei
Faculty of Arts, Computing, Engineering and Science
Sheffield Hallam University, Sheffield, S1 1WB, United Kingdom
c.r.roast@shu.ac.uk t. 0114 225 5555 f. 0114 225 3161

Introduction

The use of any novel interpretative framework such a cognitive dimensions, relies upon meeting a variety of requirements: being available to novice users; providing evidence of validity, and; having a sound theoretical footing. The variety of work looking at cognitive dimensions has addressed these requirements. However it could be argued that perhaps the least progress has been made in the theoretical foundations for the dimensions. In this paper we argue for the potential to strengthen theoretical accounts of the dimensions by comparing two differing characterisations.

The value of a theoretical view of the cognitive dimensions is to enable their character to be expressed independently of a specific application. The level of independence allows the dimensions and their use to be given a foundation that can inform the body of work. As an approach to exploring such a foundation we consider two particular cases of modelling[1] the dimensions:

- CiDa - an approach to formally examining dimension definitions, motivated by the objective of teasing out system based features that may correspond to cognitive dimension instances/examples.[2]
- "Concept-based Analysis of Surface and Structural Misfits" (CASSM)[3]. A methodology for supporting analysts in understanding a system in a context of use in cognitive dimensional terms. The approach includes a level of tool support which for the purposes of this work embodies a semi-formal model that can be contrasted with that of CiDa. Note that, the CASSM model that referred to in this paper is only one element of the CASSM approach, which goes someway towards characterising the same cognitive dimensions.

Although these two approaches vary considerably in style, motivation, scope and, to some extent philosophy, they are still relatively well defined at an analytic / symbolic level. Bringing the two models together strengthens the exploration what a cognitive dimension theory could offer and depend upon.

The models and their differences:

The two frameworks differ in their nature and main objectives. The motivation for the CASSM model is that of supporting the analysis methods that identify sufficient information about a system and its context of use for a cognitive dimensional assessment to be made. By contrast, CiDa is motivated by the potential value of having a declarative definitional formal model sufficient to allow for detailed analysis of the dimension concepts purely from knowledge of a system's behaviour.

These differences reveal themselves in other aspects of the models.

CASSM has a strong "analysis" assumption driving its use. As a result, the approach as a whole encourages an understanding of a specific use context, domain and system is adopted. Hence, CASSM is naturally scoped by a specific example of interaction and the analyst is required to make judgements about the nature of end user goals and the relative importance of possible interactions. In this way CASSM also supports the formative analysis and assessment, providing explanations of why specific dimensions are evident and some support for reasoning about design improvements. Such a characterisation is open to the criticism of being reliant upon claims about both the context of use and system design.

By contrast CiDa is not focused upon the analysis of examples systems but upon characterising dimensions to support their detailed analysis. CiDa thus attempts to be less "context dependent" in its treatment of dimensions and provide a less pragmatic basis. CiDa's approach enables dimensions to be viewed as properties or features of a system that are independent of a specific approach to validation or assessment. CiDa characterisation is sufficiently abstract to support both the formal analysis of dimension characterisations and also their rigorous empirical assessment.

It takes one to know one

For the purposes of this exploration we shall not consider a unifying theory but simply look at progressively combining the two models. Cases of the dimensions of *knock-on viscosity* and *premature commitment* are taken as an illustrative starting point for this.

Knock-on Viscosity

Without detailing the formalism by which both treatments of viscosity are expressed associations

[1] Here we take "modelling" to be, providing accounts of the dimensions that attempt to characterise them in a semi-formal manner with a view to facilitating conceptual clarity and re-use.
[2] C. R. Roast. "Dimension driven re-design - applying systematic dimensional analysis." Psychology of Programming Interest Group workshop, 2002.
[3] A. Blandford, I. Connell and T. Green "Concept-based Analysis of Surface and Structural Misfits Tutorial notes". Interaction Centre, UCL, 2004.

between them can still be established. One initial simplification will be adopted - the entity attribute perspective used by CASSM will be limited to just Boolean attributes (aka properties); this allows the attributes to be "matched" easily with the propositions used in CiDa.

Within CASSM knock-on viscosity relies upon establishing conditions: that an attribute (A1) is **modifiable**; that the modification **affects** another attribute (A2), and; that there is a **domain constraint** on the affected attribute.

The formulation in CiDa involves similar conditions but not involving an established understanding of domain constraints. The CiDa account describes: "A1" as the *focus goal*; "A2" as a *contextual goal*; and also identifies an action "C". The conditions for knock-on viscosity in CiDa become: (i) that all combinations of A1 and A2 being true or false are possible within the system; (ii) it is possible that A2 is true while A1 is not and following the action C, A1 is true; (iii) it is impossible for the A2 to remain true following the action C.

The first of these conditions expresses a level of independence between the two attributes, something implicit in the CASSM description. The second condition indicates that the action C can directly influence A1 in situations in which A2 is true. This appears to match CASSMs requirement that A1 is "modifiable", though it is restricted to the specific action C. The final condition constrains the notion of knock-on viscosity to one in which the action C upon A1 will always change A2 from being true to being false.

There appear to be valuable overlaps between the two accounts. CiDa does not depend on the identification of "domain constraints", but as such constraints are not at the system level CiDa characterises the attributes as independent. The role of action (as a named element C) in the CiDa account relates closely to the CASSM notion of "modifiability" - which is characterised as not simply changing A1 but acting-on A1.

Premature Commitment

Examining premature commitment shows similar links. Premature commitment for CASSM involves two entity attributes (B1 and B2). With the conditions that: B1 cannot be set by the user; whereas B2 can be set by the user, and; that there is a **device constraint** between the two B1 and B2. A **device constraint** means that the values of attribute B1 are limited by value of B2. One further condition is that the attribute B1 is not a fixed value within the system but can change within what the device constraint allows.

Within CiDa the same concept of premature commitment is characterised in terms of two attributes (B1 and B2) and an action. CiDa conditions include: (i) that neither attribute is true to begin with; (ii) that the system allows all combinations of B1 and B2; (iii) every way of setting the B2 attribute involves the other attribute B1 becoming true at some point before this as a consequence of the action.

One of the key distinctions is that CASSMs account is focused upon the attribute B2 being the subject of a "setting" action (with B1 having no corresponding setting action). By contrast CiDa's account emphasises the action as one that in effect constrains B1. Hence, what CASSM treats as a "device dependency" between two attributes, CiDa treats as an action influencing the attribute that cannot be set. Complementing this difference, CASSMs requirement that the device constraint upon B1 is not fixed is provided by CiDa's requirement that all combinations of the two attributes are possible.

Conclusions

These two outline examples serve as evidence that there are significant overlaps between these characterisations and also some interesting differences. CASSM clearly benefits from the encoded expert understanding of the system design and context of use, as characterised by **device dependencies** and **domain constraints** respectively. The absence of these concepts in CiDa results in CiDa being less bias towards a particular view of the domain or device, though at the cost of not providing a strong basis for characterising the patterns of cognitive dimensions other than at a behavioural level. Such characterisations are not always easily established, but it could be argued that CASSM concepts are equally hard to establish as definite system characterisations. Another key difference comes from the treatment of actions by the two approaches. CASSM has a relatively generic view of an action as including agency, a subject and an effect; by contrast CiDa treats actions as discrete user inputs capable of modifying system state.

Examining these two frameworks in this way should place us in a position to identify how each may benefit from the other in terms of supporting more accurate modelling. However, a more significant question is how together they inform the study of cognitive dimensions.

Modelling and analysis using cognitive dimensions has been a rare and difficult activity largely due to methodological "gaps" between: a relatively complex conceptual framework, loosely defined methods and limited definitive evidence.

However, we would claim that, by placing approaches such as CASSM and CiDa together a stronger conceptual framework can be developed. In particular, their combination provides an improved basis for theory development in which the driving motivation behind each contributes to the validation and grounding of both.