# Uncertainty and the capability approach to design

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**The concept of 'design for sustainable well-being and empowerment' seeks to harmonize distinct ideals using the capability approach framework, of which an important element is technology. To increase the freedoms or effective capabilities of individuals, the aim is to design artefacts and technologies. However, in this article, the argument is that due to the inherent uncertainty such optimistic outcomes cannot always be guaranteed and technologies can fail in practice and diminish human capabilities. Design trade-off and affordance of artefacts are used here to demonstrate that the use of capability approach to design is merely a static analytical tool.**

**Keywords:** Affordance, capability approach, design, trade-off, uncertainty.

## Introduction

THE 'design for sustainable well-being and empowerment' conference which was held in June 2014 at the Indian Institute of Science, Bengaluru, discussed how design can provide solutions to human development. For example, artefacts and technologies that abound everyday life and are formed through creative process of design, are closely associated with modern society's conception of development. In general, these artefacts are developed in response to the needs (real or perceived) that arise due to dissatisfaction with a certain state of affairs. Nonetheless there are multiple perspectives to conceptualise development in relation to technology (e.g. appropriate technology movement), and thus the same artefact or technology can appear conflicting or complementary to development goals. To explain such contradictions, the case of biomass stoves can be useful. In the 1970s, use of stoves that burn biomass (wood or organic residue) became a concern in relation to the issue of deforestation[1]. International aid agencies accepted the deduction that decreased woodfuel consumption would lower down the rate of deforestation. The response to predicted catastrophe was to disseminate at a large scale 'improved' fuel-efficient stoves to the 'third world' population. While in the late 1980s scores of 'improved' stoves were abandoned by users across continents, curiously at some places the 'improved' stoves had succeeded in reducing cooking time and thus lowered women's unpaid labour. Since the performance of 'improved' stoves was measured in terms of fuel consumption, energy conservation, and decrease in the rate of deforestation, its impact on well-being and quality of working conditions inside kitchen, where women routinely spend considerable time every day, was disregarded[1].

The 'improved' stoves were deemed unsustainable just like 'traditional' biomass stoves, because they had insignificant impact on environmental agenda, and were dubbed as a failure. As a result major donor agencies completely cut off their funding. In hindsight from the perspective of human development, clearly these judgements were problematic as issues of sustainability, well-being and empowerment were defined in this case on contradictory and conflicting criteria. How can design respond to such situations? First, is by appreciating the fact that artefacts or technologies it creates are neither neutral nor value-free. For example, despite the fact that household work is a gender issue, 'improved' stoves were promoted as a technology to conserve energy rather than one that reduces domestic labour (of women). Second, by acknowledging that in practice a good amount of uncertainty is involved in regard to how technologies shape up and whether they fail or succeed. The present article details out this second perspective in relation to the capability approach (CA) to design.

In order to explore the issue, this article is organized into six sections. The second section briefly introduces the concept of CA to design, and the third section describes the notion of uncertainty. Using the concepts of design trade-off and affordance fourth section explores the interrelationship between design and uncertainty. The fifth section discusses the relative scope and limitations of CA to design through a case study. And the final section presents a brief summary of the discussion and lists the conclusions.

## CA and design

Economist and philosopher Amartya Sen[2] argues that in a world that we live in today, we should be dissatisfied with the 'persistence of poverty and unfulfilled elementary needs, occurrence of famines and widespread hunger,

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violation of elementary political freedoms as well as basic liberties, extensive neglect of the interests and agency of women, and worsening threats to our environment and to the sustainability of our economic and social lives'. His theoretical framework for human development, known as CA, is 'a broad normative framework for the evaluation and assessment of individual well-being and social arrangements, the design of policies, and proposals about social change in society'[3]. The focus of CA is on the effective opportunities that people have to do or to be what they value, termed as capabilities.

But is there any inherent relationship between technology and human capabilities? According to Oosterlaken[4], there is a positive correlation because technology contributes to 'capability expansion'. She further makes it clear with a question – 'After all, what is technology for, if not increasing the capabilities that we have as human beings?' Hence the basic proposition is that, artefacts and technologies augment human capabilities and thus lead to well-being, which coincides well with the central object of the CA. Moreover, because artefacts and technologies are 'resources whose properties can be moulded', it is possible to produce effective freedoms by paying attention to the 'details of design' during development of a new technology or redesign of an existing technology. For example, van den Hoven emphasizes that, by redesigning the ultrasound machines used in Indian hospitals, the possibility of its misuse for female foeticide can be eliminated and unfreedoms produced by the existing design can be removed[5]. This perspective has been called as 'capability sensitive design' by Oosterlaken[4]. This article rather jointly refers to all such perspectives which link the CA to technology or artefact design as – the CA to design.

Importantly, in order to effectively realize capabilities and achieve valuable functionings, as Robeyns elaborates, resources (e.g. technology) would need to be in alignment with personal, social and environmental 'conversion factors'[3], e.g. possibility for a differently abled girl in a remote village to attend school. Further the resources (e.g. artefacts) must not hinder or hamper person's capabilities in any way. But, is there a way to ensure that artefacts would not hinder capabilities? Unfortunately the answer is 'no', and this is where uncertainty enters into the picture, which is the focus of this article.

## What is uncertainty?

Science, technology or artefacts are all human interventions to bring order, predictability, and control over the future, which may or may not succeed. In practice, a well-trained fighter pilot can commit an error, enemy missile might shot it down, or bad weather conditions can destroy the jet. Largely these factors are called as 'risks' since they are known or their chance of occurrence is calculable. Risk is inherent to the design of complex technologies such as civil structures, and is generally expressed in terms of the probability and extent of the system failure. For example, at Koodankulam nuclear power plant, the designed capacity for reserve cooling water to avoid core melt down is considerably lower in case it faces Fukushima type prolonged situation, and thus is a calculated risk[6]. Thus, risk can be defined as an apprehension of an (undesired) event expressed in terms of probabilities and consequences.

Recently Murphy and Gardoni[7] have applied the CA for assessment of societal impact of risk associated with design. Here we are interested in the aspect of uncertainty. Uncertainty is part and parcel of everyday life. Whether we choose to remain ignorant or respond with some sort of an action, we and our surroundings are subjected to inevitable changes, e.g. climate change. To an extent, it is possible to anticipate consequences produced by our active interventions or actions, which can be further categorized as – intended and desired, not desired but common, not desired and improbable[8]. However, since interactions between system (e.g. artefact), environment and humans are not fully predictable, certain unanticipated consequences would also manifest. Such unanticipated consequences can be categorized as – desirable and undesirable[8]. So uncertainty can be defined as, an apprehension of an (undesired) event which cannot be definitely expressed due to the insufficiency of knowledge. For example, cigarette smoking which was considered 'healthy' even by the doctors in the 1930s, turned out to be a major health risk for the individuals', a 'unanticipated undesirable consequence'.

In general, the possibility that artefacts or technologies would fail to work is always considered as a given risk, as is partly evident from Murphy's law. Nevertheless, the consequences of failure might get scaled up or completely new consequences may emerge. Thirty years back, in December 1984, nobody could have guessed the extent of devastation the disaster at the Union Carbide plant in Bhopal would bring. Bhopal disaster generated several consequences that were unanticipated as well as undesirable. Here, since the discussion is focused on everyday artefacts and technologies, we will restrict the scope to – uncertainty in terms of undesirable consequences produced by fully functioning artefacts or technologies. Thus, the uncertainty under discussion here is the uncertainty of artefacts functioning in known and unknown environments, and thereby the negative consequences produced by it, which cannot be predicted, measured, or known beforehand; it is known only as after effects. Only when we have knowledge of such after effects, these effects either become risks, hazards or danger. The following section takes forward this understanding in relation to design of artefacts and technologies.

## How design and uncertainty interact?

The CA to design thesis holds that a 'capability sensitive design' of artefacts and technologies would provide means for expansion of real freedoms that people have, and in turn positively affect their well-being. However as discussed earlier, artefacts and technologies also manifest certain unanticipated consequences, which may or may not affect human capabilities. Any unanticipated consequence of artefact that positively affects capabilities is of course welcome and desirable, and thus can be safely ignored in this discussion. The possibility of artefact or technology producing negative and undesirable consequences though cannot be dismissed, even when it is uncertain. Thus design of artefacts and technologies becomes crucial to our discussion. Forty years ago, Victor Papanek[9] wrote: 'there are professions more harmful than industrial design, but only a very few of them…by creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air we breathe, designers have become a dangerous breed. And the skills needed in these activities are taught carefully to young people.' While one single designer per se is not responsible for the problems that beseech us today, the skills available to designers and the ideas that rule their mind create a lasting impact on society.

In the design process, the designer has a particular prominence because, as Nigel Cross[10] notes, 'Everything around us that is not a simple untouched piece of Nature has been designed by someone'. The designer exerts influence on artefact since it has been 'designed' in a way that she desired or intended. In regard to consequences, if the designer had pursued a particular artefact configuration, anticipating fully the consequence produced by it, then she had intentionally brought them into reality. But if she had not anticipated those consequences, then they are unintended. Thus, unintended consequences produced by artefacts and technologies are one particular way to identify and adjudge uncertainty in design. However, the designer is not the only exclusive designer in practice because often users turn into a designer, e.g. using coffee mug as a pen stand. Thus there are two important perspectives to interpret artefacts and technologies (i.e. that of designer and user) and to analyse uncertainty in terms of unintended consequences. These are explored here using the dimensions of design trade-off and affordance.

### *Design trade-off*

Usually trade-off is a balance between two desirable but competing features (e.g. torque versus speed in automobile engines), but it can also produce a third unknown effect, e.g. increased emissions. In practice the designer faces a variety of demands and requirements against which she operates. Her creativity must devise a configuration that will satisfy a long list of criteria, including: Design for/to – ergonomics, aesthetics, manufacturability, cost, maintainability, reliability, safety, quality, usability, society, sustainability, BoP, development, capability sensitive, etc. These multitudes of constraints cannot always converge in an ideal situation, and the resulting design solution will generally be a compromise or trade-off – reflecting prioritization of one criterion and partial or complete ignorance of other relevant criteria or principles, both knowingly and unknowingly. Though such trade-offs are accepted in real life practice, however, they can also produce unintended consequences and uncertainty. For example, modern concrete houses are fast replacing old hatched roof type buildings in Indian cities and are inadvertently taking away habitat of house sparrows[11]; or while Indian Railways crisscrossing through jungles provides connectivity to far flung areas, it also proves to be the altar for wild life (e.g. elephant, which is ironically the mascot of railways) crossing the tracks in their natural habitat[12]; or hydropower projects generally regarded as sustainable energy source can also cause irreversible damage to the environment and aggravate natural disaster[13].

Therefore unfortunately in practice, things (artefacts) often end up doing more than what we tell them to do, i.e. produce unintended consequences. A general strategy to alleviate such problems is to revise the design or generate alternative design solutions. Morello[14] elaborates this design thinking from Gilbert Simondon's thesis: 'passage of time and repeated design processes make technical objects undergo successive modifications...gradually more in tune with the context in a process of reciprocal adaptation.' Two assumptions are implicit in Simondon's argument: (i) design revisions would occur independently of entrenched power relations or practices, and (ii) alternative or revised design would not create any new problems. But in practice that may not happen always. For example, majority of public buildings in India are not friendly to differently abled persons despite regulations; not even government institutions like assembly hall of Tamilnadu[15]. Similarly, transition in India from vernacular climate-responsive designs of dwellings that use rubble walls and mud roofs to modern design that uses brick walls and RCC roofs, while on the one hand increases durability but at the same time also produces 'adverse impact on embodied and operational energy consumption'[16]. Hence, neither successive modifications in design nor their positive effects thereafter can be guaranteed de facto. Popularly such consequences are termed as side effects. However, precisely because they are the outcomes of designed artefacts or technologies, their factuality must also be attributed to design. Unintended consequences thus partly result from the trade-off made during the process of designing.

### *Design and affordance*

Apart from the designer, users of the artefact or technologies are the most influential actors and often enforce or motivate redesign. Accordingly, unintended consequences then are not just tied to the designer's intentions or design trade-off. In practice, things can also be put to use by users for a purpose other than one intended by the designer. In this context psychologist James Gibson's[17] 'Theory of affordances' is useful to understand this phenomenon. He defined affordance as 'an action possibility available in the environment to an individual, independent of the individual's ability to perceive this possibility'. These 'action possibilities' share a direct relationship with agents (i.e. users), and are dependent on their capabilities likely influenced by 'conversion factors'. Don Norman[18], who used the concept of affordance in the context of human–machine interaction, notes, 'To Gibson, affordances are a relationship. They are a part of nature: they do not have to be visible, known, or desirable. Some affordances are yet to be discovered. Some are dangerous. I suspect that none of us know all the affordances of even everyday objects.'

It is from this open space of object affordances that a second set of unintended consequences arise. First, when artefacts and technologies are intentionally put to use (by users) for doing something for which they were not originally designed. So, a ceiling fan becomes a tool to commit suicide, or ultrasound machines are used for foeticide than improving baby's health, or acids are used to deface women than scientific experimentation, and so on. Of course all these artefacts or technologies were never designed for the described purposes. But in all such cases the user appropriates affordances available in the artefact's basic configuration and intentionally utilizes it to generate consequences that she wants to achieve. In the second scenario things become more complicated though, when users use technologies for purposes other than those intended by the designer, and face consequences that they never desired. Anabolic steroid used for treatment of chronic diseases by doctors, has become widely popular amongst bodybuilders and athletes for a variety of reasons. However, apart from plaguing the sports with doping scandals, steroid abuse causes serious adverse effects on user's body including cardiovascular dysfunction, liver dysfunction and reproductive difficulties[19]. Again popularly such consequences are termed as misuse of artefacts and technologies, but at the same time specific configuration and properties of the artefact do play an important role and thus have relevance to design.

Various examples illustrated above showcase how design trade-off and affordance actually produced negative or undesirable consequences for the larger society, even though the effects might be desirable to a particular designer or the user. Now, two things should become clear from the above discussion. First, uncertainty precedes and is distinct from risk. Second, the unintended consequences that are negative or undesirable cannot be fully determined and controlled beforehand, and reflect the aspect of uncertainty in design. We term such consequences as (un)intended–undesirable consequences, that stem from the artefact or technology design and its use in actual practice. The 'un' in parentheses accounts for differences in the intentions of the designer and the user. Since all the artefacts and technologies discussed above feature in everyday life, it is possible to link their effects to human capabilities. In general, we can posit that quite often than not artefacts and technologies will produce (un)intended–undesirable consequences, and thus consequently would diminish human capabilities and well-being. The following section takes this understanding forward using a case study.

## Scope of CA to design

In the previous sections, the aspect of uncertainty in design of artefacts and technologies was discussed in terms of (un)intended–undesirable consequences. It was also suggested that such unanticipated consequences consequently diminish human capabilities and well-being. This theoretical understanding is further extended in this section using a real-life case study. The case pertains to tube/bore well technology, which allows farmers and households to draw water from a considerable depth below the earth's surface for irrigation and drinking purposes. It is thus an enabler technology, which has immensely benefitted people and enhanced individuals' capabilities as well as basic level of functioning. Nonetheless, it has also brought (un)intended–undesirable consequences for a large population, effectively diminishing their capabilities. Following discussion provides details of the case, which are then utilized to outline the limitations of the CA.

### *Case of tube/bore well technology*

In the absence of sufficient and reliable public irrigation services (e.g. dams and canals), technology of tube well allows farmers to have their own private irrigation systems. In comparison to traditional water wells, tube well allows farmer to draw water from a considerable depth below the earth's surface, by tapping water from deep aquifers. The 'green revolution' in India during the 1960s, with its aim to make country self-sufficient in food grain production, provided stimulus for using tube wells. The state of Punjab became the success story in the process, which today supplies a total of 20% of wheat and 12% of rice production in the country. While high-yield varieties of seeds and supply of chemical fertilizers was the key, dependency on rainfall and lack of irrigation facilities would have made crops vulnerable to failure. The tube well technology along with subsidized electricity solved the water problem. It resulted in a remarkable improvement in agricultural productivity, and achieved food security for India's poor population. However now over the decades, availability of water through tube wells in Punjab has resulted in 'overexploitation' of precious land resources and its consequences are now difficult to manage. The Columbia Water Centre notes that, 'From 1982–1987, the water table in Central Punjab was falling an average of 18 cm per year. That rate of decline accelerated to 42 cm per year from 1997–2002, and to a staggering 75 cm during 2002–2006. Water tables are now falling over about 90% of the state, with Central Punjab most severely affected'[20].

This serious groundwater table depletion, an (un)intended–undesirable consequence of technology, is now affecting livelihood of huge population. Locally it has created socio-economic inequities. Sarkar[21] in her study found that, as the water table goes down many tube wells become dry and the small and marginal farmers, who cannot further invest in well deepening, face lower yield and profitability. In cases, the resource-poor farmers are forced to buy water from rich farmers or 'waterlords', and any further water depletion means farmers who cannot sustain farming have to lease out or sale their land, sometimes even forcing them to work as a labourer. Additionally, falling water level means more energy consumption to draw the same amount of water from depth, and has increased energy requirements in the state putting a burden on environment. On the other end, excess water has also caused issues of water logging and salinity, 'which have emerged as a major impediment to the sustainability of irrigated lands and livelihoods of the farmers in south-west Punjab'[22]. At a broader level too, water depletion threatens to affect the poor population of India because, Punjab is the largest contributor of grains to the subsidized public distribution system (PDS) run by the government. These (un)intended–undesirable consequences over the long term thus have produced net reduction in capabilities and impacted sustainable well-being. Mitigation of what is called as the 'Punjab Water Syndrome' requires application of policy instruments as well as alternative technologies. But as argued in this article, there is no guarantee that the alternative design will not pose new problems as complex elements like pesticides, fluorides and heavy metals have started to contaminate groundwater[23]. The lack of knowledge in the past and present, required to formulate sustainable practices, shows the persistence of uncertainty.

Apart from irrigation applications, tube/bore well technology also made possible for the rural population to have access to safe drinking water across the seasons. During 1960–1970s government agencies in the state of West Bengal, and the neighbouring Bangladesh started to install and promote use of tube wells. No doubt these efforts were aimed at enhancing functionings and the well-being of the rural population. However, in 1982, dermatologist K. C. Saha from Kolkata (West Bengal) came across patients with skin lesions. Further studies established that the naturally occurring arsenic in the Ganges delta has contaminated groundwater, and water fetched by tube wells contaminated with arsenic made this population vulnerable 'to several cancers; toxic effects on the liver, skin, kidney, cardiovascular system, and lung; and fatal poisoning'[24]. A Geological Survey of India report notes that, 'The estimated population in these eight districts (of West Bengal) was around 40 million (population survey, 2006), within which people using high arsenic contaminated water (above 50 ppb) was more than one million, while the estimated population using moderate arsenic contaminated water (between 10 and 50 ppb) was around 1.3 million'[25]. Across the border in Bangladesh, this particular consequence came to notice only in the 1990s. A Lancet article, based on the research conducted by Habibul Ahsan and his team, notes that, 'An estimated 35–77 million people in Bangladesh have been chronically exposed to increased concentrations of arsenic through drinking water'[24]. The World Health Organization (WHO) described this tragedy as the 'largest mass poisoning of a population in history'[24]. Clearly, a simple tube well technology has created a situation, where millions of people have lost their capabilities and basic functionings.

## *The CA to design and limitations*

The case of tube well elaborated above raises questions about what went wrong. How should we characterize and attribute these undesirable consequences – as failed state mechanisms, or wrong choices made by people, or to the technology itself? First, we must appreciate that technologies are always in relation to humans. Humans, including both designers and users, enter into a relationship with technologies, and only then it becomes meaningful to talk of a 'successful' or 'failed' artefact or technology. As philosopher of technology Don Ihde[26] says – 'were technologies merely objects totally divorced from human praxis, they would be so much "junk" lying about. Once taken into praxis one can speak not of technologies "in themselves," but as the active relational pair, human-technology'. Hence, no artefact or technology exists or can be evaluated, in isolation to humans. Second, we should not reduce this interrelationship to 'absurdly contradictory' positions, viz. 'guns kill people' versus 'people kill people; not guns', as Bruno Latour points out with reference to gun control debate in the USA[27]. Rather technologies and human beings are intertwined, and it is through 'technical mediation' that actions and consequence are produced, e.g. no shooting is possible without 'a gun' and 'a gunman'; both actively contribute to it and none is neutral. In the tube/bore well case it must be emphasized here that, the (un)intended–undesirable consequences were not known to any entity beforehand and are after-effects. However, at the same time, it was only due to the 'technical mediation' of this artefact (i.e. the tube well), that these consequences manifested. How CA to design can respond to it?

First solution is redesigning of artefacts using a 'capability-sensitive' approach. But for the population already exposed to the (un)intended–undesirable consequences of the existing technology, which has diminished their capabilities and functionings that perhaps cannot be restored, redesign is of no relevance. Alternative design or redesign of artefacts and technologies, that are 'capability sensitive', usually benefit the unexposed population (to the existing technology) or the future generations. Nonetheless, as elaborately discussed in the fourth section, even a 'capability sensitive' design cannot overcome the aspect of uncertainty, because the undesirable consequences generated by design trade-off and affordance are unknown and remain unanticipated. This does not mean that new designs are not necessary – such inertness will only sustain and subject people to undesirable consequences of existing technology. Rather it suggests that, we should not propel the illusion of 'new and improved' design to be the magic bullet.

Why CA to design cannot overcome these problems? First, because they are fundamental problems of technology rooted in the desire to control the future. As has been argued here, interactions between system (e.g. artefact), environment and humans are not fully predictable, and due to the dynamics involved certain unanticipated consequences would also manifest. Absolute prediction and control of the future using science and technology is thus impossible. Second, because CA is a 'normative framework for the evaluation and assessment'. Thus, one, it provides a static evaluative analysis of the state of affairs at a given point in time, and secondly, it can only assess what is known. Any evaluation of individuals' well-being or proposals about social change in society is affected by the availability of resources and the existing conversion factors (personal, social and environmental) at the time of evaluation, e.g. being healthy (by drinking safe water). Thus, the picture of a person's well-being in CA is a function of the static input data fed into the analysis, e.g. a person can choose to drink water from water well or tube well. Because a person chooses functionings from his capability set (in our specific case, a set enabled by artefacts and technologies) that are valuable to him, we have limited way to foresee how different opportunities and constraints presented by chosen functionings affect the well-being and sustainability aspect, e.g. contracting cholera by drinking well water, or developing cancer by drinking tube well water in Bangladesh. Thus, CA cannot address uncertainty, e.g. unanticipated and unknown fact that Ganges delta has arsenic deposits. Nor can CA conceptualize dynamics, e.g. overexploitation of resources or contamination of groundwater over the period of time.

The CA for design is definitely useful as a design for *X* (value sensitive or capability sensitive) tool to generate and assess variety of design requirements for different sets of users. At the outset it is a rich framework for the evaluation of artefacts and technologies from the perspectives of human functionings and capabilities. However, CA to design cannot generate an exhaustive list of capabilities that an artefact will create, either during the design phase or after complete realization of the artefact (e.g. after manufacturing), because of the inherent affordance produced by various elements of the artefact. More significantly, CA to design cannot generate beforehand an exhaustive list of capabilities which an artefact would diminish, whilst it is being designed, constructed or used. Consequently in a good number of cases, CA to design would produce type-II errors or false-negative results, i.e. attributing an artefact or technology as an enabler of capabilities, whereas in practice it ends up diminishing the well-being of a person or a group of people, and hampers sustainability in the mid or long term. There is thus no assurance that a 'capability-sensitive' design in practice would not diminish human well-being.

## Discussion and conclusions

Amartya Sen's conception of human capabilities views development as expansion of real freedoms. CA to design extends that conception to 'technology as capability expansion'. The pertinent question then is what kind of goods we can expect from CA to design? In this article it has been argued that even 'capability-sensitive' technology need not always expand capabilities in practice, and that technologies are both solution and cause of the problem. Using the concept of design trade-off and affordance it was demonstrated that in practice artefacts and technologies can produce unanticipated and (un)intended–undesirable consequences. Such consequences reflect inherent uncertainty, which results in diminished human capabilities and well-being. Hence, the assertion that a 'capability-sensitive' design in practice would not diminish human well-being cannot be made. In conclusion, while CA to design as a static analytical tool can be used to generate set of design requirements and evaluate the artefacts and technologies in relation to known or anticipated outcomes, it can neither weed out uncertainty nor accommodate dynamic conceptions of capabilities.

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ACKNOWLEDGEMENTS. The author acknowledges the financial support received from the University of Twente, Enschede, The Netherlands, and the Indian Institute of Technology Delhi, New Delhi, India.

doi: 10.18520/v109/i9/1665-1671