A Case for Affective Responsive Architecture

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ABSTRACT
This paper makes an argument for a novel type of responsive architecture, incorporating affective computing[13], where user affect (emotion) becomes a consideration in the management of real-time environmental response. Affect is seen as a necessary component in certain architectural contexts, notably in healthcare environments, where concerns of person-environment fit, and the contribution to wellbeing made by congruent and user-centred design are paramount. The response generated to contextualised real-time sensing of the user can enable continuous remodelling of environmental adaptation to meet changing user needs. The positioning of the user at the centre of the model in this fashion paves the way for the emergence of an architecture which constitutes an Open Work in the sense described by Eco, where the user, through sensor-enabled response, becomes intimately involved in design outcomes[4].

Author Keywords
Responsive architecture; affective computing; user-centred environments; HCI; smart environments.

INTRODUCTION
Human beings have always modified their environments, ranging from the simple action of closing a shutter, or pulling a blind, to the complexities of contemporary responsive facades, which are continuously modified in response to external context. While architects often view the finished built product as a static entity, users continue to modify a building over its lifetime, in response to changes in patterns of use and in user characteristics, in addition to changes in the external environment. Negroponte's model of responsive architecture [12] envisages a built environment which incorporates computing in order to respond on a continual basis, so as to better address functional need by means of environmental modification.

Intelligent systems, which manage actuation of applications in the built environment, are a prerequisite for the making of responsive architecture. Smart environments imply sensing of the user as well as the context: intelligent decision-making and system response is predicated on contextualising sensed user data, in order for the system to determine an appropriate response in terms of actuation of applications. Furthermore, in order to engender continuous and real-time response, where HCI is involved, a cognitive sensor network, with distributed system intelligence and an emergent/dynamic system architecture [7] are further prerequisites, in order to manage multiple devices, platforms, software, sensors and interfaces.

CONTEXT
In designing responsive architecture, context becomes a central consideration, determining the appropriateness of an interaction or interface [11]. If responsive architecture is reframed as interaction design, this produces an infinite number of potential design outcomes, which will vary, as in interaction design, according to context, user and function/activity.[11] This reflects, though in a novel sense, the manner in which in architectural design outcomes have always varied according to context and usage. For environmentally embedded interaction, context has the same meaning in both architecture and ICT, that is, it implies a particular physical locale [11]. Where architecture becomes the user interface, user characteristics must be given equal consideration, in order for architectural responsivity to support any set of desired interactions.

Scale, as an aspect of architectural context, produces possible scenarios which range from detailed interface design in the personal space of an individual, to collective, and collectively interpreted interactions of a group of people with a building, space, or sequence of spaces. While the range of possible outcomes is

therefore potentially infinite, typical approaches to certain user-context relationships may emerge over time, as new architectural typologies.

USER-CENTREDNESS AS A DRIVER FOR RESPONSIVE ARCHITECTURE; THE INCLUSION OF AFFECT

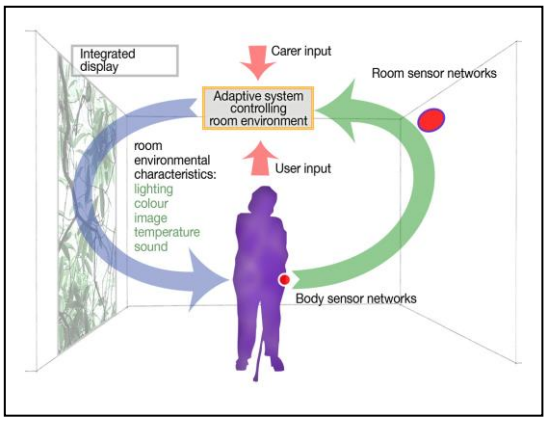

FIGURE 1 THE MYROOM CONCEPT

Responsive architecture which embodies intelligent response to contextualised user activity thus effectively becomes an exercise in interaction design, where the entire space or building becomes the user interface. Usability then becomes a prime concern, in place of bare functionality. In certain architectural contexts, it becomes apparent that interaction must be supported by sensing of user affect, or psychological status, in addition to sensing of user activity, so that the system supporting interaction must also have the capacity for affective computing. The basis of this argument is that person-environment fit, or congruence, is not achieved merely through catering for functional fit, which addresses more basic needs, but more comprehensively, by also aiming to maximise psychosocial congruence[9]. Sensing of affect allows the possibility of response to a user's psychological needs, which is especially pertinent in certain contexts, for example, in environments for persons with dementia, or for children with autism spectrum disorders. In either case, the user may not be capable of articulating needs, either functional or psychosocial; in both cases, unmet needs can lead to a burden of undue stress on the person, impacting negatively on wellbeing. The connection between built environment and wellbeing has been established and continues to be researched, in the emerging discipline of Evidence-based Design, which may be defined as 'a process for the conscientious, explicit, and judicious use of current best evidence from research and practice in making critical decisions, together with an informed client, about the design of each individual an unique project' [15].

While users already adapt buildings during occupation, managed response enabled by sensing calls into existence another creative space for the architect, where continuous and future interaction can be designed for, both anticipated and unanticipated. Interactive architecture enabled by ICT will always involve elements of serendipity, which contribute to the Vitruvian principle of "delight". A relevant example is that of responsive facades, where the impetus for design is most often that of environmental modification for reasons of energy-efficiency and sustainability, though ultimately to maximise user comfort. The design outcome nonetheless creates a constantly–varying aesthetic, where a large-scale façade composed of repeat elements shifts and changes over the course of the day or season, and as it does, reflects patterns of change in the natural context. There is something inherently appealing about such an aesthetic; this may in itself relate to human aesthetic preference for natural landscapes[17] and the fractal patterns[5,14]of which it is composed. As such, it offers intriguing possibilities for design, all the more as the technologies used to mediate response become intimately bound up in aesthetic outcomes.

Where affect becomes a consideration in the management of actuation, it extends the existing capacity of architecture as a setting for human action and interaction within the built environment. When enabled by real-time sensing, facilitating continuously-evolving response, it creates the potential for ongoing adaptation managed by conscious design intent, endowing architectural design with an active temporal dimension. This is consciously explored in contemporary responsive architecture, such as the work of Jason Bruges Studio http://www.jasonbruges.com/, while Connolly Cleary's, "Pourquoi-pas Toi?" a room-scale video installation, draws the user, through processing of sensed user movement, into the making of the final aesthetic outcome. http://www.youtube.com/watch?v=I1aurLR1Pw4

Affective responsive architecture also allows the possibility of offering varying solutions to problems which only become overt through use, or which arise over the course of time, through changes on the part of the user's ability to interpret or interact with the built

environment. At its best, issues of usability will be comprehensively addressed, with both functional and psychosocial fit forming implicit and often indivisible aspects of usability. The inclusion of affective computing in management of real-time response in internal environments enables that response to become truly user-centred, as any change actuated will inevitably reflect patterns not only of usage, but of user affect. It also permits the possibility of environmental response which is actively therapeutic, and designed to respond to negative affect. As before, this is of particular concern in the design of environments for people with dementia, who are prone to outbursts brought on by the cumulative stresses of the day. In order to be truly user-centred, responsive environments for this group must not only attempt to minimise environmental stress, but actively set out to promote attentional restoration and relaxation. To successfully design such responsive environments, the architect must draw on knowledge from a variety of disciplines, including environmental psychology and ICT, which currently do not form a standard part of the architect's education.

THE "MYROOM" PROPOSAL

FIGURE 2 MYROOM PARTIAL PROTOYPE

In a scenario where affect is used to direct the nature and pattern of architectural response, the ongoing transaction between user and environment becomes explicit in the built context. In the MyRoom scenario[2,3], system and environmental response aspire to supporting both functional and psychosocial need, orchestrated by an intelligent system, through real-time response to user needs. User interaction, including affect, becomes embodied and manifest in architectural response in the individual's "personal life-space". This might include environmental response which anticipates "catastrophic events" for a cognitively–impaired user, through using machine-learning to learn from patterns of behaviour, and facilitating actuation based on predictive analysis of user status. In turn, the environmental response is envisaged as acting on the user, closing the feedback loop between user and context, a feature of much responsive/interactive architecture[1]. In this scenario, the built outcome becomes to a degree "self-prototyping": as the system "learns" from contextualised data, the environmental response is informed by intelligent decision-making. Sensing of patterns of affect also allows objective observation of user reaction to design intervention, static or responsive. Affective computing[13] is already being used in research on the effect of website design and advertising on users, as well as research on the efficacy of therapeutic interventions on cognitively-impaired user-groups. Affective responsive architecture can thus offer changing solutions to problems which may only become overt through use, or which arise over the course of time through changes on the part of the user's ability to interpret or interact with the built environment. In technologically-enabled responsive affective architecture, there exists an unprecedented opportunity to move on from "machines for living"[8] to "living machines", centred not only on the user's functional needs but also on changing affective state.

A rudimentary prototype of part of the MyRoom concept, which addresses aspects of psychosocial congruence, is currently being tested at CCAE. It is based on actuation in response to real-time sensing of HR, as proxy of stress. Subjects are required to carry out a selection of tests (mathematical, visio-spatial, and social) designed to induce stress. Breach of a predetermined individual threshold value for HR actuates a short video piece, which is intended to be de-stressing/restorative. The visual content is presented at large scale, as it is intended to be immersive, and ideally should be close to room scale. Preliminary findings indicate that that effects may be subjective, and possibly personality-dependent, much as the reaction to stress induction appears to be. Viewing of the piece also prompted free association and reminiscing in one subject, which is of particular value in attentional restoration, according to Kaplan's Attention Restoration Theory (ART)[10]. The ultimate intention is to create a responsive

environment where therapeutic content can be delivered in direct response to user need. In a real-life situation, architectural embedment of user sensing is seen as desirable, not least because of identified user preference for sensing methods which do not require wearable sensors. Such an approach is in keeping with aspirations towards "Calm Technology"[18], in a "quiet architecture", as described by Malcolm McCullough in "Digital Ground".[11]

Responsive architecture which is aware of user affect may thus begin to address alleviation of stress of environmental origin in a considered manner. In the particular case of elderly people with dementia, who constitute and ever-growing sector of first-world societies, that need is all the more pronounced as the course of the disease is one constant decline in cognitive function, and diminishing ability interpret and manage the environment, including that of the personal life-space. As the person is no longer able to adapt to his/her environment, the only available solution is for the environment to adapt to him/her. Sensor-enabled environmental responsivity makes this a viable proposition. Adaptation or intervention should furthermore be appropriate to the degree of impairment [16]; once again, interactive response affords the possibility for changing intervention over time. Real-time architectural response, based on contextualised sensing of the user, also affords the architect the vision of an environment capable of managed and continuously evolving modification, in response to changing user needs, not just on a minute-by-minute basis, but also over longer periods of time.

CONCLUSION

Inclusion of affective computing is therefore proposed as a necessity in any scenario for responsive architecture which aims to be inclusive or user-centred. This paradigm is most appropriate for a vulnerable user in a care setting, but has potential application in many other contexts, including that of the workplace, where inappropriate stress is of concern, impacting as it does not only on performance, but in the longer term, on wellbeing and health in general [6]. Once the possibility of gauging user reaction exists, it is difficult to ignore in any context. The precise nature of the interplay between user and environment will vary from one context to another. In healthcare contexts, affective environmental response has a place in design for the acute patient in short- to medium- term accommodation, as much as in the delivery of appropriate solutions for person-centred responsive architecture in long-term term i.e. residential settings, where the cumulative effects of lack of functional and psychosocial congruence can result in stress, and stress-related illness, and thus impact negatively on individual wellbeing. The ongoing dialogue between user and environment might also be orchestrated so as to draw on other, or all, senses, and might thus also be appropriate in retrofit situations, to compensate for sensory deficiencies in design, particularly in existing care settings. Expression of the transactional relationship between a specific user and context should always reflect both context and purpose. Where sensing of the person becomes a critical consideration in the ongoing management of the transactional relationship between person and built environment, the resulting architecture becomes a truly Open Work, in the sense described by Eco[1], the user thus becoming an active participant in the final design outcome.

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