HCI Design Methods: where next? from user-centred design and beyond

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ABSTRACT
This paper discusses the developments in HCI and new media design. HCI design evolved into human-centred and creative approaches to the conceptualising and building of user interfaces. De Haan [1] identified a number of factors underlying the changing nature of HCI design in moving towards ubiquitous computing and the internet of things. HCI and new media design focussed on light-weight product as mashups of readily available functions and services, and design became a prototyping, feature-driven and an iterative/incremental activity, with a highly flexible and exploratory approach to product design. Three factors describe the changes in design methodology: increasing extension of user-centred design, increasingly higher level software tools and frameworks, and the application of agile design and design exploration. For each factor, a supporting practice-oriented design method is discussed to illustrate the possible future developments in HCI design. In conclusion, the paper proposes several recommendations regarding the further development of HCI design.

Author Keywords
design method, user-centred design, agile design, new media design, ubiquitous computing, internet of things.

ACM Classification Keywords
H.5.2. User Interfaces: Theory and methods.

INTRODUCTION
In this paper we will investigate design and design practice in HCI and new media design. New media design is taken as more or less synonymous with HCI design, even though, technically speaking, HCI design also encompasses user interface design for products where the nature and functionality of the hardware, rather then the medium or the software determines the possible outcomes of the design process. De Haan [1] discusses a number of new developments in HCI and user interface design in relation to the use of ICT outside the traditional formal work environment by what is usually entitled ubiquitous computing, pervasive design or ambient intelligence. The analysis discusses a number of changes regarding the nature of the user interface and a number of associated changes with respect to the design methodology.

ICT started with highly expensive mainframe computers to move along office-oriented mini's and personal computers as workstations, subsequently absorbing the fun factor of the game computer and the always-on communicating opportunities of the smartphone, the field seems to move towards an information ecology or intelligent ecosystem which encapsulates all aspects of life, including our personal, social, intimate and even subconscious parts of our existence.

Underlying the new developments in HCI and user interface design, six factors were identified, applying to the nature of the user interface[1], as follows:

- Tangible and embodied interaction
- Mobile and networked connectivity
- Smart as intelligent interfaces
- Smart as sensitive interfaces
- Social and collaborative applications
- Connected data

Tangible interaction allows for new and more humane interaction channels and modes to be added, such as (multi) touch interfaces, interaction by speech and gestures, and interaction based on sensing and object- and face recognition. This provides not only a much broader collection of input modalities but also a more embodied, physical and less symbolic mode of interaction.

Mobile and wireless networks allow one to use ICT independent of specific location as behind the pc or at the computer centre, enabling always-on connectivity to other people, things, places and information sources, as the essential precondition for the development of ubiquitous computing, ambient intelligence, pervasive design and the Internet of Whatever.

Social and collaborative applications allow computers to be used beyond their original role as number crunchers, and especially due to using computers for communication purposes, allows people to deploy ICT for social uses. Examples include, staying in contact with distant friend and relatives but also to share work as well as memories, experiences and affections and facilitate social care among patients suffering from e.g. dementia or autism. Intelligence as smartness lets people use ICT in the classical AI role of intelligent agents, assisting humans with
the knowledge and insights of others and by smart combinations and accumulations of observations to reduce some of the uncertainties of living.

**Intelligences as sensitivity** allows one to use computers not only as intelligent tools but also to use them as social and affective agents, displaying behaviour that looks like or feels like human emotional behaviour. Smartness as sensitivity also opens opportunities for using ICT in non-purposive manners, with ‘unintended interaction’ as a by-product of being spotted at a particular location, detected by a camera, etc.

**Connected data** enables computer systems to present information beyond what is directly available. Utilising distant data and services in standardised ways to inform people where to go and where not to go in large crowds based on the density and movement of smart phones, where to find the nearest public toilet based on location-information, Open Data about council facilities, etc. Internetworks made it easy to exchange and compare heterogeneous forms of information between different computer systems and different sensor systems.

In addition to the changes in HCI regarding the nature of user interfaces, de Haan [1] also distinguished three main factors underlying the developments in the design methodology of user interfaces:

- User Centred Design, co-creation and co-design
- Software patterns, frameworks and libraries
- Agile design and design exploration

**User Centred Design** as a factor addresses the idea that concern with the user, or rather, the customer or consumer, is becoming more and more important to the extend that user centred design and usability evaluation have evolved into user experience design, co-design and even co-creation and personalisation where the user actively determines the design outcomes. When the hardware cost diminish to such an extend that computers are available from 20 euros (cf. Raspberry Pie or your average smart phone) they become commodity products that one buys as an accessory instead of to attain particular working goals in a most efficient manner.

**Software patterns, frameworks and programmer interfaces** allow programmers and designers to work at increasingly higher levels of abstraction and enable the non-specialists to create their websites and mobile apps, leaving programming to be mainly concerned with linking together different services and functionalities from various libraries and frameworks. Application programming becomes creating mashups from the functions offered by programming frameworks, libraries and services and their APIs.

**Agile design and design exploration** allow designers to be less concerned with some pre-specified list of requirements and pay attention to understanding and addressing the actual usage of applications. Design success is what eventually works well in the hand of the customer, and to find out, designers had to gain access to how applications are being used in real-life settings. State of the art design approaches start with co-designing in concept labs to fine-tuning in living labs and eventually evolve into continuous adaptation on the basis of usage data, during deployment.

This paper is concerned with exploring the state of the developments as regards the nature of new media and HCI design methodology to investigate general trends and to attempt to predict the direction of the developments and make a number of recommendations as regards the future of HCI design practices.

**FLEXIBILITY IN NEW MEDIA DESIGN**

De Haan [2] states that New Media Design products like interactive websites and smartphone apps are easy to adapt to the context of use and the requirements and tastes of different users and user groups - very much unlike other design products. The basis for this characteristic is that new media designs almost always consist of mashups. Regardless if it concerns an Internet of Things application, an app or an interactive web application, each program consists of a small central core, containing the programming logic, in combination with a number of different services, each connected in a client-server architecture by a API: a programmers interface. The first reason for easy adaptation to ever-changing user concerns is that for programs designed as mashups, if a particular service (hence: function) is no longer according to ones tastes, it is very easy to plug in another one. Likewise, during design several optional services may be tried-out without too much costs and effort.

The second reason why it is easy for new media products to be flexibly adapted to changing requirements from user and context is that mashups consist of multiple service interfaces connected to one central core which contains almost all presentation aspects of the app. Consequently, the way in which the application presents itself to the end users, is dealt with at one place only: in the core or the front-end of the app. As result, in new media programs there is a perfect distinction between the functionality and the presentation, which is required for flexible design of the user interface aspects of computer programs [3]. If another ‘look and feel’ of an application is required, all there is to do is to change the front-end. Since the front-end in new media products often consists of a script instead of compiled programming code, user interface adaptation may consist of little more then textual changes. While a website is up and running, it is possible to present different groups of users with a different front-end, depending on, for example, which local webserver they use or what preferences the group has. Online optimization is not restricted to a single trial but may take the form of a continuous process of adapting the looks and behaviour of a website or mobile app to the behaviour of its users. Because of this particular characteristic, in new media design there is no strict
distinction between the phases of designing an application and using it: the context of design includes to the context of use.

Finally, new media products allow for very flexible design because different functions may be designed and implemented, relatively independent of each other. A computer program that consists of many different and relatively independent functions does not have to be designed and specified at once. As such there is no requirement that the design specifications or the programming specs should be complete or should even be consistent at a particular time. As such, the media design process allows for a features-driven process, where each design cycle (or Scrum sprint) focuses on the next most important features to implement using user-centred design and agile design methods like Scrum [4] and Extreme Programming [5]. The main implication from the relative independence of the building blocks of new media applications is that the design process may proceed piece by piece: incrementally and iteratively. In comparison to e.g. structured design methods, there is no need to complete early steps in the design process before moving on to later steps.

Because of the flexibility in terms of functionality, ease of adapting the presentation of the user interface, and a flexible and user centred design process that does not require completed process steps, designers can use a variety of special purpose tools, such as concept drawings, task lists, persona descriptions, partial design results, wireframes, interface sketches, function lists and use cases, paper prototypes and demonstrators. As a consequence of the flexibility in HCI design, the design process of HCI and new media products share three characteristics:

- the design process is based on prototypes, from low-level prototypes to increasingly higher-level ones to the end product
- the design is features-driven, where each design cycle addresses the next most important features and functions
- the design process is iterative and incremental both within as well as between or over design steps

Design starts with a novel idea or a concept. This may be a concept intended to solve a specific predefined problem or it may be a concept as a plain novel idea. The design process will evolve into a more or less finished result in the form of a demonstrator or a working prototype of the concept or it may be a product that is ready to market. Between the start and the result is a number of logical design steps, a number of design steps that have a necessary (hence: logical) order of occurrence: analysis, requirements, design, implementation, installation and evaluation, as prescribed by various structured approaches to software analysis and design (cf. [6]). According to Rob [6] it was only until the arrival of object-oriented approaches that the logical order did no longer correspond to the physical or temporal order of stages in actual design. Because of the inherent flexibility of HCI, the same considerations apply: in new media and HCI design, the temporal order of specifying a design may actually be driven by the outcomes of preceding design activities.

De Haan [1] referred to this process as exploratory design where design activities are driven by the outcomes of preceding design results as in artistic design in which e.g. a painting is gradually shaped by what is already on the canvas. Exploratory design or the systematic and continuous exploration of design options during the whole design process is necessary when there are many unknowns in product design, such as when novel techniques are used or when users are presented with new kinds of products; as is clearly the case in Ubiquitous Computing and the Internet of Things (see e.g. [7]). Exploratory design is a consequence of new media design neatly following the Seeheim model in which the functionality and the presentation of the functionality are independent in applications [3].

**NEW MEDIA DESIGN AS EXPLORATORY DESIGN**

The most important consequence of the flexible architecture and design processes of new media designs is the distinction between the development of the design as an idea or a concept and the development of the design as an implementation of the concept. In HCI design, conceptualization or ideation, on the one hand, and the process of implementation or building are two relatively independent processes. Naturally, early in design, the development of ideas will be predominant and implementation will be more prominent in late stages but without there being a necessary or logical order of the steps within the two processes.

Ideaion is (mostly) concerned with enacting methods such as paper prototypes, role-playing games, interface sketches, storyboards, whereas implementation is about how to translate ideas into ‘something that works’ including the choice of methods, tools and techniques to translate the conceptual ideas into working software. Both processes delineate the (remaining) design space and determine the boundaries of the design solution. As an example, an idea for a mobile app may be that it does something; it “acts” when two persons are in each other physical vicinity. Why and how the application will act will be determined during ideation. However, the technique used to determine when people are near one another will probably be determined and fine-tuned much later, and this may be implemented using Wifi hotspot ID’s, GPS localization or an aGPS service, etc. and which technique will be used depends on the context of use, including the platform, available hardware, required speed, etc.

Since ideation and implementation are relatively separate processes, it is possible to envision design as two semi-parallel streams, each ending with its own design result or design product. In the case of implementation, it is running code whereas ideation delivers a complete user specification: the design as a specification of what the users will experience, when they interact with the end-product.
From the user's point of view, ideation is the most important design process in HCI design because it specifies the design of the application at the level of abstraction of the user instead of at the level of abstraction of the system or the software architecture. As such, ideation is best supported by what I would like to call: enact: laying out, demonstrating or sketching what the design will do, what it will look like and how it works without referring to the implementation details. Enacting is like following a user scenario with the would-be product design. Early on in the design, enacting may take the form of paper prototypes, or the application may be acted out in real life. Later on in the design process, enacting may take the form of demonstrating the design with a scale model, presenting a prototype, showcasing a partial solution or presenting a demonstrator to show what the final product would look like.

The two previous sections discussed the two main characteristics of new media and HCI design: design is a highly flexible undertaking which focuses on the creation of ideas and concepts of a product design without a need to consider how the ideas and concepts have to be restrained in order to implement them in software code. As a result, HCI design may take place in an iterative, incremental and a piecemeal manner that allows for exploration throughout the design process; very much similar to design in the creative arts where the result is gradually shaped by a constant assessment of what has been created thus far. In the following sections, the discussion is about the practical approaches to HCI design that may be regarded as the result of the flexibility and the conceptual nature of design.

**DEVELOPMENTS IN HCI DESIGN**

HCI design has come a long way since it separated from software engineering design and it has been described by a variety of words indicating what seemed to be prima focus at the time, including: linear, structured, cyclic, spiral, user centred, rapid, agile, contextual, task-based, participatory, empathic, etc. etc. Three factors may be distinguished as independent or orthogonal to explain the current changes in HCI design due to the rise of ubiquitous computing and the Internet of Things [1].

First, amongst others because HCI products are entering the personal sphere, the user-centredness of design becomes increasingly more important.

Secondly, software design is no longer concerned with large monolithic systems and is towards more flexible and modular products, and HCI design has evolved into a lightweight practice of mashing-up readily available functionalities and services by selecting appropriate programming frameworks, patterns and APIs (Application Programming Interfaces).

Finally, the increased flexibility in program design and in the design process itself made it possible that concept design became rather independent of the implementation in software with the result that the HCI design process was no longer driven by design process considerations (as in structured design) but by considerations regarding the most relevant features of the to-be design product and by the outcomes of exploring the design space as in Agile and exploratory design.

Each the following sections will discuss an instance of how each of the factors: User Centred Design, Software patterns and frameworks, and Agile design and design exploration, may be translated into a actual and practise-oriented techniques for the HCI design to exemplify that HCI design needs to have such techniques incorporated.

**User Centred Design, co-creation and co-design: Users as Designers**

The user-centredness of HCI design has always focussed on involving users within the design process and reshaping the process such as to enable users to be part of it. User-centred design has culminated in two different design approaches. First, in co-creation, designers keep their responsibility to design the form but the end-user is to provide the content. More important is the co-design approach in which users as stakeholders or domain experts become part of the design process, and designers are only responsible for the non-user elements of the design process, such as coordination and administration or the technical and the research aspects of the process (cf. [8]).

A good example of a co-design practise is the Users as Designers approach by Waag Society [9] in which Creative Design is regarded as a research and design approach for Open Innovation in which users participate on the basis of number of principles:

- Get initial inspiration and feedback from a small number of users
- Involve users early and continuously in the design process
- Visualise and prototype your ideas as early as possible to test them
- Work in multidisciplinary teams and share the knowledge
- Get in the head of your future user and let the user experience new possibilities

On the basis of these principles, a design process is proposed that consists of three steps: Ask, Make and Try; each step identified by what is the main focus of the particular design phase. The Ask-stage inquires the needs of users and opportunities to develop, using methods such as Exploratory Play and Context Mapping. In the make-stage, or rather the thinking-through-making stage, Ideation, Prototyping and Business modelling are used to devise creative solutions in the form of concepts, demonstrators and service-blueprints. Finally, the try-stage is dedicated to testing and evaluating by means of a variety of methods for field testing, engaging and tinkering and adaptation to create optimised prototypes and plans for further steps in the production of the design.

What is important in the 'Users as Designers' approach is that it embodies the idea of co-design: a design process
which does not merely involve the end-users in order to acquire user requirements and to do user evaluations but a design process which actively involves users as domain and task experts throughout the whole process of understanding, shaping and fine-tuning the product at stake.

**Software patterns, frameworks and libraries: Network Focused Design**

Network Focused Design (NFC) [10] is a good example of a class of design approaches intended to design and redesign products for a networked world. The methodology is not aiming for designing out of the blue but rather to investigate a design context in terms of actors and relationships, picking out the interesting ones and reworking them in novel and networking terms and, finally, designing the elements for a good user experience [10]. Important about design methods like NFC is that they aim at innovation rather than design per se, by incorporating the notion that the internet and the Internet of Things do not require completely novel types of products but rather clever innovations of existing products making the most of the new opportunities of the internet, such as localisation, connectivity, identification and personalisation.

In this respect, the average webshop, health-app or online taxi-service are not *that* different from their pre-internet versions, except, of course, for making smart and innovative use of network connectivity. Here, design is nothing more (and neither nothing less) than re-connecting existing elements and functions in creative and innovative ways. In this way, Networked Focused Design embodies the idea that product design is generally not about creating museum-worthy exaltations of a brilliant mind but rather that design is usually about finding a functionally and aesthetically pleasing solution to a design equation with multiple factors. As such, design may rather be an engineering or optimization activity in finding a proper combination of sensor techniques, resource combinations, data-sets and functionality or API choices. This is largely a matter of choosing, weighting, comparing, and testing and evaluating; in short: the exploration of design options or exploratory design.

**Agile design and design exploration: Living Labs and Innovation Experiment Systems**

A living lab is a development and evaluation environment, situated as part of real life. Instead of bringing the test-subjects into the laboratory, in living labs, the research questions and the experiments are brought into real life. Starting with extending the notion of a usability lab into a home in which people can live as a laboratory to investigate how people use computer products that are designed for use in ones personal live (cf. [11]), the living lab has evolved into an environment for learning and development in the form of a delineated part of reality, provided with facilities to observe and register the behaviour of real people using new product designs as part of real life [12][13].

Most of the methods and tools for collecting data about user performance and preference are explicit; that is: users are involved in an explicit way, a living lab for development also provide opportunities for getting insight into human behaviour in an implicit and less obtrusive manner. By embedding a sensor network in an environment, it is possible to track users’ patterns of interaction with usage of appliances and movements from one location to the other. When such a sensitive environment is used for research purposes and the research laboratory is moved into the real life world, the living lab environment may be used as both, a tool for research tool and as an environment to develop emerging technologies [14]).

The living lab approach demonstrates the notion for a early and continuous involvement of end-users. It is only by introducing users to the product being designed that they may get a good understanding of how it may be used, and only by using actual usage data from genuine users, will it be possible to improve the usability and user experience of the product [15].

**An Innovation Experiment System** (IES) is a practical approach, developed by Jan Bosch and colleagues [16] as an answer to what there is beyond agile design. According to Jan Bosch [17], the crucial factor in surviving as a software company is being able to rapidly and constantly update and improve ones products on the basis of genuine user and usage data. Whereas improvements in the efficiency of an evaluative process will only yield linear improvements in economics, because each future evaluation cycle will be a percentage cheaper. On the other hand, improving the speed with which user data of a new design can be collected and incorporated in new designs will result in much bigger and exponential improvements in process economy because revenues will increase when products are released earlier - instead of only cheaper.

As such, it is argued that software and service companies should move beyond agile design and use research and development as an innovation experiment system. Instead of focussing on software versions and collecting features that customers wish to see in future versions, in innovation experiment systems the development of requirements is driven by exposing customers to partial implementations of functionality in order to use their instant feedback for determining the value of a particular functionality [16]. In other words, possible product improvements are constantly build into the product and provided to customers, so that their data may be used to measure (cf. in an AB testing setup) if the improvement is worthwhile. Innovation experiment systems are rather similar to what was identified as a main characteristic of new media product design like websites, mobile apps, etc. in which the design process does extend into the maintenance period when the usage data of websites are used to fine-tune the design or determine the choice between different versions [1].

Both the idea of using a Living Lab as a place to shape the design of a product as well the idea of using real user data to determine the direction of design in Innovation Experiment Systems illustrate the necessity of experiencing novel products in a real life situation in order to determine
for both, users and designers, how the product might be improved.

DISCUSSION
In this paper we argued that Ubiquitous Computing and the Internet of Things has changed HCI design, both concerning which products are designed and concerning the process according to which the products should be designed. From the area of new media design it is clear that the design process became a much more lightweight and flexible process: an iterative, incremental and prototyping-based process that is driven what is relevant to the end-product rather then that it is driven by some process requirements. On the one hand, in exploratory design and design exploration, the whole design process from ideas to working code is determined by explorations in the design space, including actual usage data. On the other hand, in agile approaches to design, the design process is determined by what are the next most important features for the end-product, which is not only used to set the goals for the next design cycle or sprint but which also determines if the design is completed. The term Creative Design has been suggested to refer to such conceptual, exploratory and incremental methods for designing HCI products [1].

The changes in HCI and new media design were described as the result of three more or less independent factors. First, there is a trend to extend User-Centred Design beyond focussing on the users' requirements, task performance and the working context. HCI design is increasingly focussing on the user experience; i.e. the subjective experiences of flow in handling HCI products. In addition, users are not merely the focal point of design but also actively involved in co-creating and co-designing the results of the design process. The increased and renewed attention for User-Centred Design was exemplified by design approaches such as the Users as Designers approach by Waag Society [9]. Users as Designer is not only a user-centred approach but it also, explicitly, intended as a Creative Design method.

Secondly, where design used to be characterised by the question of how to create the software to enable people to interact with the computing machinery, the question of how to translate the user issues into the how-to of building software is becoming less and less important with the availability of programming tools at increasingly higher levels of abstraction. Building software is still a skill but because of the availability of tools to support software patterns, programming frameworks and programming interfaces (API’s) to readily available services, building software is no longer an art. As a result, designers are no longer bound to implementation considerations and may focus on the development of concepts and ideas.

The role of designers as the eclectic and creative engineers is exemplified by Network Focused Design [10] in which products design consists of creating valuable combinations of sensors, services and data, and the connectivity of the internet. In NFC the focus is neither on pure technical engineering nor on designing out of the blue but rather on designing as making novel and intelligent networked combinations of existing functions, services and faculties. It may not seem very creative to designing product by mashing-up existing elements. Nevertheless, the NFC design process is clearly a form of Creative Design.

Thirdly and finally, it was argued that HCI design did evolve into a flexible and concept-driven activity according to an incremental, iterative and piece by piece design process. The focus of a design project at a certain stage of development is no longer dictated by the deadlines for the deliverables of the particular design stage. Neither is HCI design about resolving all the design issues around a single monolithic product as it used to be the case in structured design. Instead, the flexible nature of design as mashing-up freely available functions, services and other design resources allows for exploratory approach to design in which design issues are addressed on the basis of relevance to the end-product and may be resolved by exploration, experimentation and tweaking.

On the one hand, HCI design as exploration is exemplified by the Living Lab as the real-life environment where designers can develop, explore and test concepts in a sensitive environment in which the actual user- and usage data may be used to assess the design choices and direct the process [12,14,13].

On the other hand, a more extreme example of design that is driven by user-data is the proposed Innovation Experiment System [16,17] as a method to catch product design, evaluation and innovation in a single process driven by collecting actual data from real customers using commercial products over the internet. With respect to the creativity of the design approach, the Living Lab is both, a good example of a Creative Design method as well as a required element for such an approach. The Innovation Experiment System method is more problematic. When the direction of the design process and the choices therein are prescribed by the user data and preferences in actual use, as the method seems to imply, the Innovation Experiment System is not a creative or a user-centred approach but rather an optimisation approach to user performance. Applied without proper and creative interpretation, the process may simply lead to the most average HCI design ever created.

CONCLUSION
The introduction of Ubiquitous Computing and the Internet of Things brought several changes to HCI design, including: a renewed attention for user-centred design, the use of ever increasing higher level tools, and new design methods that support agility and exploration as part of the design process. Particularly in new media design but also in HCI in general, the mashup-architecture made the design process much more flexible. When different elements of a design can be created relatively independent of each other, the need to adhere to a strict and sequential order of design steps disappears and may be replaced by a collection of
lightweight tools which turn design into an incremental, iterative and exploratory collection of activities. With a very flexible process and a similar flexibility amongst user interface elements, HCI design is freed from many implementation considerations and may focus on the development, selection and fine-tuning of ideas and concepts.

For each of the three main changes to HCI and new media design, (a class) of methods or approaches was discussed to support the relevance of the change. For at least three out of the four methods discussed, the creativity of the design process is facilitated. They support Creative Design in facilitating the conceptualisation, exploration and incremental development of emerging solutions. For one method, the Innovation Experiment System, which exemplifies, in extreme, how actual user data is utilized to 'dictate' the direction of design and innovation process, it is not clear how the method will facilitate Creative Design. It remains to be seen if too much adherence to actual user- and usage data will result in either highly creative or extremely average design solutions.

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