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Publication date
2020

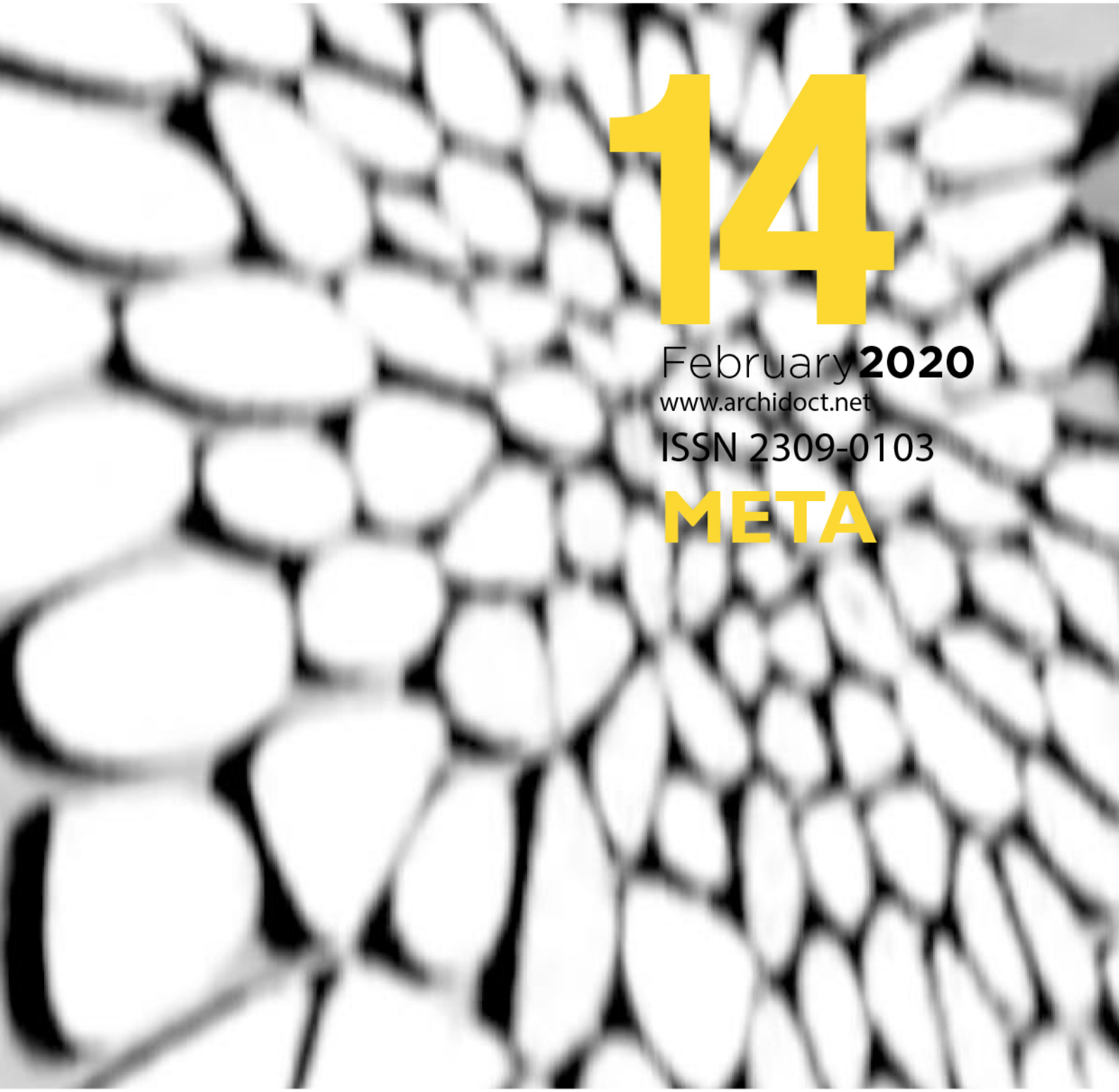
Document Version
Final published version

Published in
Archidoct

Citation (APA)
Friedrich, C. (2020). Immediate Systems Human-In-The-Loop Cyber-Physical Systems that Embed Design and Implementation in Situations of Use. *Archidoct*, *7*(2), 27-39.

archi|DOCT

The e-journal for the dissemination of doctoral research in architecture.



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February **2020**

www.archidoct.net

ISSN 2309-0103

META

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ISSN 2309-0103
www.archidoct.net
Vol. 7 (2) / February 2020

Immediate Systems
Human-In-The-Loop Cyber-Physical Systems that Embed Design and Implementation in Situations of Use

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Abstract
Design activity, especially in architectural praxis, takes place in spatialand temporal remoteness from the use of its outputs. Thisremoteness impedes the ability to respond to actual needs that arise in situations of use. Ultimately itmakes design dependent on hypothesis.Aim of this essayis to introducethe notion of Immediate Systemswhichembed design and implementation in situations of use and thus overcome the limitations of remoteness.
Immediate Systems,as defined by author, are cyber-physical systemscomprised of interacting digital, analogue, physical, and human components. As meta-systems they include people and environments in a tight loop between human intention and immediate adaptation. Immediacyin this contextindicates a state of continuously available adaptability at the speed of human intention. Such meta design systems take design methodology to an extreme whichparadoxically resembles the situation before design emerged as separate praxis.
The essaycontains three theoretical contributions. The first one proposes and frames the very notion of Immediate Systems. The second one, presents and discusses a series of examples of such systems.The third contribution, identifies conditions forand characteristics ofImmediate Systems derived from the first two contributions.

Keywords
Immediacy; immediate Systems; design by use; design environments; design methods.

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1 Introduction

The aim of this essay is to introduce the notion of Immediate Systems (IS) whichovercome the limitations of remote design by embedding design and implementation in situations of use.The essay binds into a larger research effort in Immediate Architecture which is focused on research-by-design of IS..[1]

The term immediacy here indicates a state of continuously available adaptability at the speed of human intention. Immediate differs from instantaneous in that instantaneous indicates just a temporal direct response, whereas immediate can denote a direct relationship or state which is maintained over time and can include any combination of multiple modalities, for example temporal, spatial, tactile, embedded or intentional.

IS are meta-systems; they connect and surpass, in psychological terms between the self and the other, in terms of human-computer interfaces (HCI) between user and computational systems, in ecological terms between animal and habitat,and in architectural terms that between inhabitant and built environment. The notion of IS applies to all these worldviews.For the remainder of this essay the terms user and environment will be used for generalized descriptions of IS.

In the following section of this essay, the notion of IS will be further defined, in their relevance to architecture, through the psychological phenomena of the immediacy effect and the state of flow experience, through the concept of direct manipulation developed in the field of human-computer interfaces, and by relating them to the Theory of Affordances (Gibson, 1986). The third section of the essay discusses characteristics of IS which are highlighted in description of examples. Based on the findings of these sections the essay concludes with a summary of the initial framing, of the conditions and characteristic of IS, and perspectives for future work.

2 Framing Immediate Systems

2.1 Relevance to architecture

Design activity, especially in architectural praxis, takes place in spatial and temporal remoteness from the use of its products. This remoteness makes design dependent on hypothesis and impedes the ability to respond to actual needs that may arise in situations of use.

To illustrate different aspects of immediacy, the architectural example of the igloo is considered. Developed as cultural technique in a natural habitat, the igloo is constructed entirely from snow, a material which is readily available in its builders' environment, following techniques with minimal use of tools and constructed literally as a bubble around the body of the human. It offers protection against weather and predators, has excellent insulating properties and will strengthen over time as surfaces of the enclosure repeatedly melt and freeze, reinforcing weak spots and closing gaps with newly built ice. When it no longer is in use it will literally melt with the environment, leaving no waste products. Even though an igloo is traditionally constructed with the temporal immediacy required for adaptability at the speed of human intention, it is immediate in the aspects of resource

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gathering, to the human body, in applicability, in constructive rationale, in its structural and functional self-reinforcement and in its ecological disposal.

Contemporary technological developments increase the feasibility of IS which offer the types of immediacy mentioned in the example offer even temporally immediate adaptation.Robotic building, the Internet of Things, interactive environments, to artificial intelligence, smart materials and a digitally driven circular economy, all can contribute to involve even activities of fabrication and construction within feedback loops at the speed of human intention. To design an IS is not the same as designing a specific part of the built environment, it is its meta-design in the sense that it takes traditional remote design methodology to an extreme where it paradoxically resembles a situation before design, implementation and use were separated. IS take a special case in the discussion on Cyber-Physical Systems in architecture in that they do not exclude the human user, as designers, builders and inhabitants, but conceptualize them as essential and integral to the system.

2.2 Human-in-the-Loop Cyber-Physical Systems

IS can be conceived as Cyber-Physical Systems(CPS)(Lee, 2015)comprised of interacting digital, analogue, physical, and human components. A typical CPS contains feedback loops between embedded computers and physical processes, where computers track and direct physical processes but not without being affected by them in turn. As a special type of Human-in-the-Loop Cyber-Physical Systems (HiLCPS)(Schirner et al., 2013), they include people and environments in a tight loop between human intention and immediate adaptation.

The term cybernetic, derived from the Greek word for steersman(Wiener, 2009), predates digital computers and stood for the field of control and communication theory, whether in the machine or the animal. A human constructing an igloo could be considered a Human-Physical System in which the human takes a central role as helmsman who interacts with components of the environments, navigating the entirety of the system towards habitable configuration. With contemporary technologies that make a wide range of transformations between the realms of the digital and the physical readily available, e.g. Computer Numerically Controlled (CNC) and robotic fabrication and construction, sensor-actuator networks, the Internet of Things, gesture detection and brain activity analysis, IS can be conceived as true cyber-physical systems even in the narrowest definition of the term.

2.3 Immediacy Effect

In behavioral psychology and economics, the term immediacy effect refers to the tendency of decision makers to amplify the significance of immediately experienced outcome relative to delayed outcomes. When confronted with intertemporal choices, with choices between two or more alternative outcomes expected to be realised at different points in time, experiments have shown that time discounting is not determined by comparing present values discounted by a fixed discount rate. People tend to overweigh more immediate outcomes. In this sense, regarding human behavior, there are close interrelationships and a high level of similarity between risky decisions

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and intertemporal decisions (Keren, 1995), best illustrated in the immediacyeffect and certaintyeffect. The certainty effect refers to the observation that people overweigh outcomes that are considered certain relative to outcomes which are merely probable. When offered the choice, people will assign a far higher value to an immediate outcome than to a delayed one.

Since the purpose of ISis to provide immediate feedback, an embedded user can be assumed to be affected by the immediacy effect. The directness of outcome, as the immediacy effect suggests, is preferred and may provide a sense of certainty and control. As suggested by Roberts (2014), the immediacy effect may impact the user's decision-making processes and lead them to best practices by affording quick execution.

2.4 Flow experience

Immediate feedback is one of the prerequisite conditions for the flow experience, a psychological concept developed by Csikszentmihalyi in the late 1960s. Flow is a subjective state people report when they are fully invested in the task at hand and function at their fullest capacity.

Csikszentmihalyi identified three conditions for the flow experience to emerge. A clear set of goals directs attention and adds purpose, immediate feedback promotes a sense of control and a balance between perceived challenges and skills that offers. When these conditions are met, one enters a subjective state of flow for which a series of characteristics have been found. These characteristics include intense and focused concentration, merging of action and awareness, loss of reflective self-consciousness, a sense of control over one's actions and their impact, distortion of temporal experience and an autotelic experience of the activity in that it is intrinsically rewarding and self-sufficient to the extent that it is valued higher than the original set of goals (Nakamura and Csikszentmihalyi, 2009).

IS as defined in this essaycan provide some of the conditions for flow experience to arise, but for the condition of a clear set of goals, formed by direction and purpose, they depend on the user to develop their intentions. For flow to emerge, the need for a balance between skills and challenges is brought to attention. The autotelic, intrinsically rewarding nature of the flow experience suggests that users can be expected to actively sustain the flow experience once it is established.

While the literature on flow experience presents flow as a generally desirable state which allows people to unfold their operational potential to the fullest, it also mentions as pitfalls the narrow focus and loss of reflective capacity that are associated withit.

2.5 Direct Manipulation

Computer scientist Shneiderman coined the term 'direct manipulation' (Shneiderman, 1983) for a human-computer interaction style which involves continuous representation, reversible operations through physical actions, immediate visibility of results and a scaffolded approach to learning that affords experimentation with minimal prior knowledge. As examples for such systems in the early 1980s, Shneiderman listed display edi-

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tors, spatial data management interfaces, video games, interactive CAD/CAM systems and driving an automobile. Users experience direct manipulation interfaces as lively and enjoyable. They are easy to learn, faster to operate and more satisfying to use. Immediate feedback affords users to adjust input as soon as the effect is undesired, often removing the need for instruction and error messages. According to Shneiderman, direct manipulation is both beneficial for learning situations and affords fluid and extensible operation to expert users. Even though Shneiderman did not refer to Csikszentmihalyi's flow concept, his description of the conditions and user experience of direct manipulation bears strong similarities to the psychological concept of flow experience.

A seminal essay on the topic, Direct Manipulation Interfaces(Hutchins et al., 1985), was written with the goal of giving cognitive account of direct manipulation. Itwas rooted in the assumption that the feeling of directness which emerges in direct manipulation originates in the commitment of fewer cognitive resources. Two underlying phenomena of the feeling ofdirectnesswere identified, called distance and engagement. Distance isthe information processing distancebetween intentions of the user and executions of actions by the machine. Direct engagement occurs as appropriate application of the model-world metaphor. Following this metaphor the world is explicitly representedand the user has the sensation of acting immediately upon the objects of the task domain. The other of the two major metaphors for the nature of human-computer interaction, the conversation metaphor, would have the interface act as medium in which user and system have a conversation about a not explicitly represented world.

2.6 Theory of Affordances

The IS includes the embedded user similar to the way in which an animal is embedded within its natural environment, in an environmental niche. The abstraction of habitat applies itself to formulate a holistic approach to design modeling because it indicatesa type of socio-technical systems, comprised of the interactions between people, devices, codesand processes that join them (May and Kristensen, 2004).

The Theory of Affordances(Gibson, 1986) is based on the idea of a world of ecological reality, a conception of the world through its meaningful relations to the animal. The relationship between animal and environment is reciprocal, they can only exist as each other's complement. Affordances are what the environments offers, or affords, to animals and humans.Raw materials afford manufacture, surfaces afford pose, mobility, contact and handling, shapes of certain form and size can afford protection from the elements. To a skilled animal or human, objects can afford to be used as tool or as weapon.

At the core of Gibson's theory of affordances stands the argument that affordances are invariants which are not affected by their perception or misperception.Their meanings are not to be imposed upon them; they are to be discovered. Because of this they have been described as actionable relationships(Norman, 1999)between animal and environment.

IS can be further framed through the affordances that can occur in them.

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1. Immediate Systems afford their use in a state of immediacy
Affordancesare actionable relationships between animal and environment which exist entirely independently of being perceived or misperceived. In this sense, immediate systems offer the user immediacy independently of their perception, but they depend on successful perception and activation for the user to engage with them. Being human-centered, the IS requires with the human to be in the loop. Human and IS have a reciprocal relationship. The IS can be conceived as ecological niche.

2. Immediate systems shift the boundaries between self and environment.
Gibson describes how tools in use are no longer part of the environment but become an extension of the body of the user. They have capacity to attach to the body, suggesting that there is no strict separation between animal and environment but a shifting boundary.Like Gibson's affordances, the notion of ISis based on a world of ecological reality. In an architectural setting this means that IS shift the relation between human inhabitant and builtenvironment.

3. Immediate systems can afford furnishing the environment with new affordances.
IS are essentially meta-affordant because they afford to furnish the environment with new affordances, and they afford to do so in a state of creative immediacy Architectural immediacies are special affordances for modification of the environment. They let the inhabitant to project intended affordances onto their surroundings and to explore and navigate alternative constitutions of the environment for their affordances.

4. Immediate Systems in general provide a characteristic set of affordances.
In the following section, a series of examples shall be discussed with the aim of deriving further affordances specific to IS. In the following, these affordances will be called characteristics of IS.

3 Characteristics of Immediate Systems

3.1 Introduction

In order to further define the notion of IS, a series of examples will be described and discussed. They were found in the fields of human-computer interaction, behavioral psychology, performative art, algorithmic art, architecture and industrial design methodology.

While all the following examples share the following characteristics, they are individually described by one of the main characteristics they each exemplify for immediate systems in general:

awareness, guidance, intimacy, embeddedness, mastery and **re-framing.**

A model of these characteristics can show them as complementary pairs mirrored in the tight feedback loop between the user and the environment:

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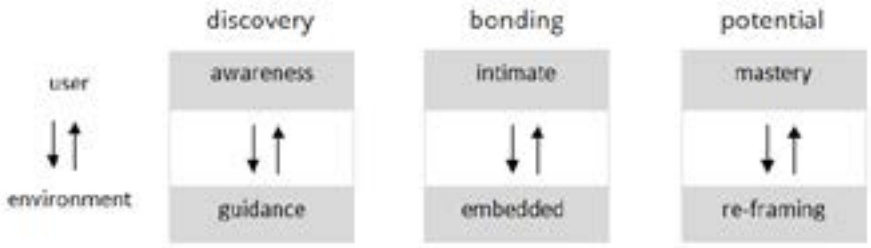

Discovery
The user's **awareness** of the environment grows through the use of its actionable properties. The environment provides **guidance** through vectors of beneficial action revealed by the interaction.

Bonding
The user encounters the environment **intimately**, as they are **embedded** in it. IS have minimal resource footprint in terms of e.g. cognitive and material resources.

Potential
The immediate system affords **masterful** action, including continuous **re-framing** of the user's objective.

3.2 Examples

Awareness – IS stimulate merging of awareness and activity

In his text Video in Relation to Architecture, Graham describes the notion of immediacy in modernist art as follows: "A premise of 1960s modernist art was to present the present as immediacy—as pure phenomenological consciousness without the contamination of historical or other a priori meaning"(Graham, 1993).Immediacywas thought to bring self-sufficiency and novelty: "The world could be experienced as pure presence, and without memory. Each privileged present-time situation was to be totally unique or new."

Graham builtart installations thatconfronted spectators with mirror images and video feedback loops. He intended to critique the modernist notion of immediacyby demonstrating that it is impossible to locate a pure present tense. He noticed that the installation challenged the spectator's awareness. Temporal immediacyallowed the spectators to see themselves as both subject and object at the same time, a sensation that is usually visually unavailable. In this way the viewer was made aware of the difference between intended and actual behavior, immediately influencing future intentions and behavior. Due to the feedback viewers could enter a process of continuous learning. Since the intentions are interior to the observer and the self-observed behavior is exterior to them, the observer's notion of interior and exterior self is challenged. The immediate mediation of images as provided by video/television takes on an architectural function, it permeates public and private boundaries between rooms and social classes.

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The installations of Dan Graham focus on performance, not production. They have no memory and the users' activity does not leave a trace. What persists is the mechanism of re-presentations in mirrors and video-cache. Still, the installations can affect experience and behavior of users through otherwise unavailable sensations, challenging their **awareness**.

Intimacy – An IS is experienced as extension of self

For British painter David Hockney (Weschler, 2009)(Figure 1) the IS isa smartphone used as canvas for painting – a convergent device which combines screen, touch interface, computer, memory and communication to deliver a coherent, fast-responding experience. The IS affords Hockney, a master-painter, to enter an uninterrupted flow of work due to the multiple ways in which it immediately embeds into his creative process. The smartphone as pocketable instrument it canalways be at hand, work can commence without the need to prepare and collect drafting equipment, and afterwards there is no waste and the output can be shared with peers. Hockney even states that it pervades the activity with a quality of freshness.The ISis experienced as an extension of the acting selfand lets the artist proceed at a natural pace that allows for the emergence of a feeling **intimacy**.

Mastery – An IS offers a sense of control

In his PhD thesis on Immediacy in Creative Coding Environments, Roberts(Roberts, 2014) combined theconcept of direct manipulation interfaces(Shneiderman, 1983)with the notion of the immediacy effect from behavioral economics(Keren, 1995), to define immediacy as "the effect of latency on the perception of control in interactive, real-time systems and the impact of time discounting on the decision-making processes of interactive system end-users. Systems that are immediate provide a sense of fluid productivity and lead people toward best practices by affording their quick execution. […] We can infer from this that we should lead users towards best practices for creative authoring by making such practices as rapid and as unobtrusive as possible."
Roberts developed a live coding environment called Gibber.cc (Figure 2) which allows simultaneous coding and code execution for creation of audio-visual content and live performances. It is set up to guide users towards an enjoyable and productive experience.

The developed live coding environment Gibber.cc allows for a certain amount of simultaneity but not for convergence of manipulation by coded instructions and representation of visual and auditory results. The interface overlays a coding pad on the visualization area, and written instructions can be added to the live execution in their entirety or as selections of parts of the code. Thus the transfer from intention to changed behavior mostly depends on code formulation in themind of the user and input via keyboard, the information processing distance (Hutchins et al., 1985)is direct only when parts of written code are selected and executed. Still the environment allows for a feeling of direct engagement to emerge. One of Roberts' aims was to lead the user towards best practices by employing immediately available actions as a form of **guidance**.

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Embeddedness – An IS is bound to and specific to its environment

Keinonen(Keinonen, 2009)suggested the term immediate design for"a mode of design characterized by responsiveness to users' current needs, intensive layperson participation, continuous incremental improvements, and the implementation of do-it-yourself developmental platforms. It takes place where the activity and challenge are on the site, and aims at solving the problem directly without withdrawing to product development fortresses."

Keinonen opposes immediate design to remote design, which is meant to produce general solutions and foundations for others to develop products or local practices. The development project for a general-purpose product ends when the product is launched, but immediate design aims atimproving specific human-technology systems and is open ended.Immediate design fosters temporal and spatial immediacy, and direct interaction between designers and users. It also changes causes for design action, as it is driven by the explicit and implicit needs of users, instead of being driven by trends, economic rationale or technology. Immediate design optimizes the human-technology match in a fluid process of continuous improvements.

In immediate design, design collaboration is not something that takes place only between designers and engineers, it takes place between designers and users. Design and use take place simultaneously, the designer acting side by side with users, separated by neither hierarchy no value. This **embeddedness** of design activities, directly in the practices of use,occurs as normal work and improvement of the environment coincide, generating specific and context dependent solutions.

Re-framing – An IS affords to continuously re-formulate the user's objective

Artist Martino developedfor her doctoral thesis research a digital drawing instrument which provides creative immediacy by maintainingthe artists' mark(Martino, 2006). Her thesis focuses on digital instruments based on the shape grammar approach(G. Stiny, 1972)(Stiny, 1980) because the immediacy of the artist's mark in visual creation has historically been lost in computation. Neither did digital design tools do not answer the fluid demands of the artistic process, nor did prior research address the immediacy of drawing and painting as a device in computational art.

According to Martino, the practice of visual creation is a shifting process, in which the artist has the role of a creator who dynamically re-creates problem space. The canvas into which a sketch is drawn changes with every stroke of the pen. This leads to new visual realizations and re-formulates the artistic task at hand at that specific moment in the process of creation, which"occurs in the tight loop between the hand and the eye where every mark influences every other mark in a re-framing of the picture plane."(Martino, 2006)The immediate, dynamic input allows the designer to operate outside of the constraints of a static model or boundary system.

A system which allows for such practice should accommodate process at both the conceptual and implementation level. Such a system should combine flexibility with repeatability and furthermore be adaptive, with an elastic schema that allows a visual

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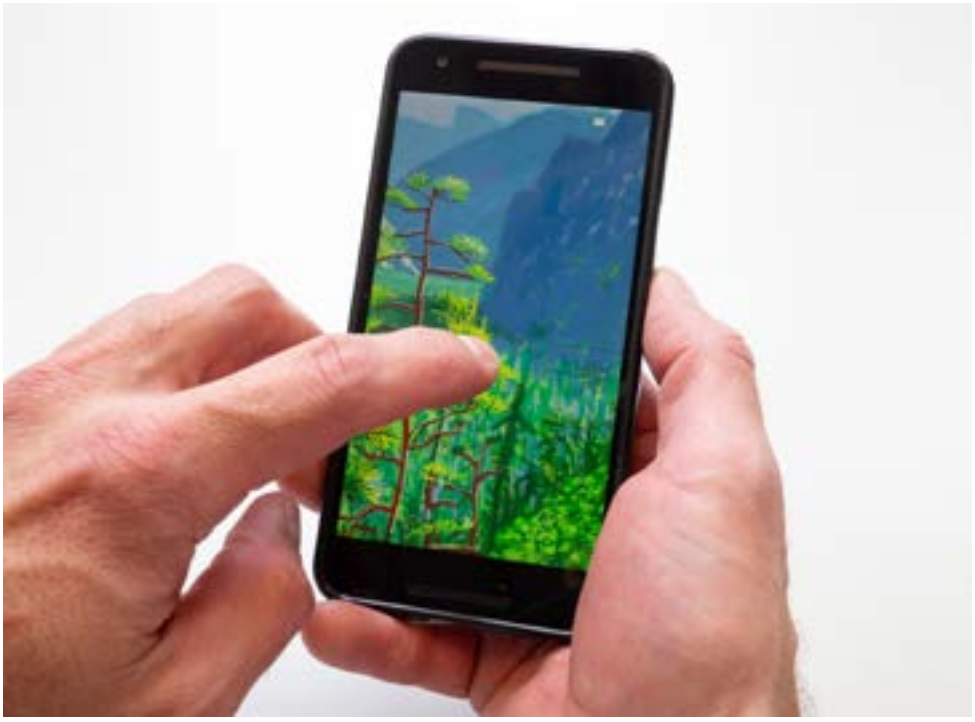

Figure 1.
A Hockney iPhone painting, opened in a drawing app on the author's phone.

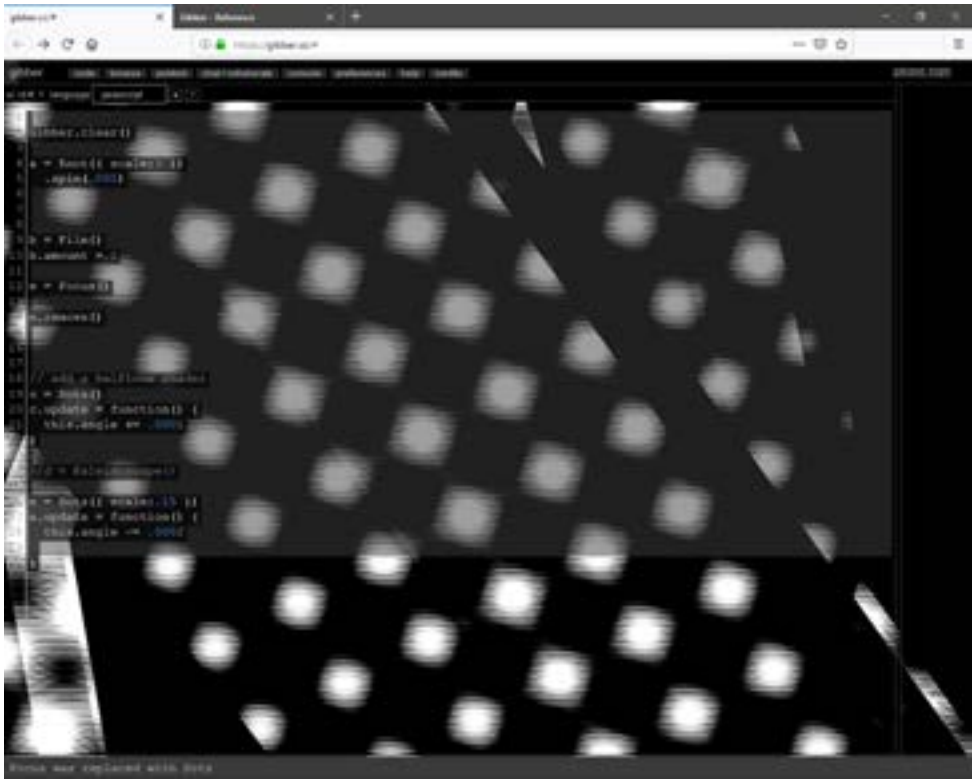

Figure 5.
Screenshot of a Gibber live-coding session

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designer to identify and use emergent features. The design environment affords the designer to continuously and simultaneously frame and solve the problem. Design and implementation coincide in this process of **re-framing**.

3.3 Overview

The examples are discussed from two perspectives: One perspective is the internal, connected view of the human users which are embedded in them, as the system shapes their experience and affects their consciousness, their behavior and potential. The other is the external and detached view which allows for analysis of system components and of characteristics of specific instances of IS on a technical level.As previously described the characteristics found in the examples can be described in complementary pairs:

Awareness&Guidance

Regarding **awareness,** all examples contain tight feedback loops which offer confrontations between intended and actual behavior. In this feedback loop adequate action is continuously validated, and it allows the users to adjust their actions accordingly, matching intentions with results. The userbecomes aware of their relationships to the environment through its actionable properties. All IS implicitly afford **guidance** through vectors of beneficial action revealed by the interaction.Some examples were attributed to lead to continuous learning, others were explicitly designed to offer guidance through the availability of immediate action opportunities.

Intimacy & Embeddedness

The examples show that IS occur with the user's body in the loop and become extensions of the body. Hence,they let the user proceed at such a natural pace that it allows for a feeling **intimacy** to emerge. From an outside perspective the user is embedded, and in this **embeddedness** as temporal, spatial, social and architectural intermediaries dissolve and roles of designer and user overlap.

Mastery & Re-framing

IS are geared for emergence of the psychological flow experience, they thus can help individuals to function at their fullest capacity and to enhance their competence. IS let users act in a mode of direct manipulation, where they are initiators of action and feel in control, gaining confidence and **mastery.** The problem space is a dynamic re-creation of problem space by framing and solving the problem simultaneously, in a fluid process of continuous **re-framing**.

4 Conclusions

Overview

In this essay IShave been introduced and framed as Cyber-Physical Systems and through the lens of Gibson's Theory of Affordances, alongside the notions of flow ex-

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perience and the immediacy effect from psychology, and related to the direct manipulation interaction style from the field of human-computer interfaces. A series of examples have been described and discussed. Based on this effort characteristics and conditions of Immediate Systems have been presented. In conclusion of the essay, the findings will be listed in short and a glimpse at future work will be given.

Initial **framing** of IS indicated that they embed design and implementation in situations of use, overcome limitations of remote design, offer a form of direct manipulation interaction style, leverage the psychology of the Immediacy Effect and Flow Experience. Their implementation as HiLCPS radically improves applicability of the concept.

As **conditions** were named that ISare meta-systems binding user and environment, provide a tight feedback loop between intention and adaptation,establish and maintain a state of continuously available adaptivity andcan include any combination of multiple modalities, e.g. temporal, spatial, tactile, embedded, intentional or procedural.
IS, framed within Gibson's original Theory of Affordances, offer the affordances toshiftboundaries between self and environment,afford creative immediacy andafford furnishing the environment with new affordances.Additional affordancesderived from examples are awareness, guidance,intimacy, embeddedness,mastery and re-framing. Outside of the section on affordance theory, these affordances were referred to as characteristics of IS.

Future Work

The presented description of IS makes it possible to position them in history and contemporary discourse. Itidentifies predecessors and technical as well as socio-cultural contributions and eventual pitfalls. It also makes it easier to relate the notion of IS to architectural research and praxis.

Additionally, the presented work serves as guidefor research on innovative architectural systems, which the author is invested in. The development of architectural systems asIS,involves the discovery of new applications and the unraveling of potential synergies of emergent technologies. Inherently itinvolvesresearch into the relationship between humans and the built environment. Hence developingISin architecture is an agenda that reaches beyond mere design and performance optimization, it requires a transdisciplinary approach relying ona constructive assessment of the quantitative and qualitative impact of technological change on architecture and its users.

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