ANALYSIS OF A RETROSPECTIVE DISCOURSE EXPLAINING AN ACTUAL PROCESS OF DESIGNING A HOUSE

As an Empirical Basis of the Development of a Situated Design Agent

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Abstract. This paper describes a situated design agent approach to understand and explain the characteristic nature in architectural design and shows some findings in retrospective discourse analyses about a design process of a real house as an empirical basis to discuss the feasibility of the situated design agent approach.

1. Introduction

The objective of the study is to explore the feasibility of a situated design agent approach towards research in architectural design. This paper describes the situated design agent approach and gives the outline of an empirical basis to discuss the requirements and expectations for the development of a situated design agent that plays an important role in the approach.

Designing is an activity to create something to change an actual situation into a preferred situation. What is produced by designing is a preferred situation itself, an artifact expected to provide such a situation, or descriptions of such an artifact (Simon 1969). Even if actions in designing look as if they are not scientific, the way of talking about them should be scientific if the claims made so as to be new assets to knowledge about designing. Gero and Fujii (2000; Fujii and Gero 2000) have been employing a situated design agent approach to understanding and explanation of the nature of architectural design process. This approach assumes that the transactional relation between a designer and a design environment makes a designer perceive a situation and that the situation may assist a designer to explore a design solution in such a way that it can be called conceptual design.
The approach is aiming to let a situated design agent – an object composed of a computational model of the processes maintaining transactional relationships with a design environment – perform actions from whose observation a process of designing is extracted. The idea is to let a design agent organize purposive-looking patterns of transaction with a design environment. The situated design agent is a computational representation of a designer in an artificial environment in a computer. It is expected that the situated design agent should produce a course of actions, which corresponds to the characteristic phenomena in a process of designing an artifact, in a certain context in the artificial environment. In other words, a situated design agent is expected to bring about the situations and the transitional relations among them that can be appreciated as the characteristic nature of a process of designing. A grammar of a language defines the language composed of infinite well-formed sentences in terms of a set of finite grammar rules. A grammar may represent the structure of the language. Similarly, a finite set of actions and transitions situations brought about by the actions may define a process of designing.

This paper is mainly composed of three topics. Section 2 outlines the situated design agent approach employed in this series of research. Section 3 describes empirical findings from analyses of a retrospective discourse about a design process of a real residential house. Section 3 mentions the implications of the empirical findings for the development of a situated design agent for research in architectural design. Section 4 concludes the paper.

2. A Situated Design Agent to assist in the Explanation of Design

A situated agent approach allows for the study of two aspects of designing: what the roles of internal and external representations may be and whether the particular experiences of a designer play a significant role in the behavior of the designer. The first is concerned with the internal mechanisms of a situated design agent, whether it performs actions that should be important elements in designing, and the second is concerned with the agent’s capacity to show evidence to support the explanation of situatedness in designing.

2.1 BACKGROUND

A phenomenological view of the relation between architectural design and an environment has claimed that a stereotypical form of vernacular architecture is an expression of human’s empirical understandings of herself/himself in the natural and cultural environment where the vernacular architecture is built (Watsuji 1935). The understandings may
be unselfconscious or tacit. Alexander (1964) regarded the stereotypical forms as the result of unselfconscious processes of making vernacular architecture. He claimed that a designer should be conscious about the things that determine a form of architecture. Researches in architecture, on the basis of modern science, have been trying to make design theories and methodologies, which are rational and abstract representations of portions of the understandings, but we could not say that they have succeeded in rational explanation of intuitive moves or strategies in designing themselves. We intuitively believe that knowledge represented explicitly for the purpose of scientific explanation does not cover everything in our empirical understandings about architectural design. Rave (1988) has shown that reasoning in an everyday life is not different from reasoning on the basis of scientific representation of how to derive the answer with respect to a given problem. These issues may, more or less, apply to design of any kind of things.

Knowledge, on the other hand, is a collection of the beliefs that are verified in an objective manner in a community or society where knowledge in question is transferred and stored. To be verified and transferred in a community, it seems that the contents of knowledge have to be explicit and public by being described in a natural language or a formal symbol system. It is true that non-verbal communication about what is understood is employed, but so-called a scientific explanation requires that the things to be explained and verified should be explicit and public. The contents of knowledge may be the representations of abstraction constructed on the basis of individual objects or phenomena that are regarded as members belonging to a same class rather than extensional representations or enumeration of the individuals. This nature realizes the economy of knowledge transfer and storage, but loses the understandings that are hard to be described explicitly.

2.2 A SITUATED DESIGN AGENT

A situated design agent is a computational model of a designer who perceives a situation, forms concepts based on the previous concepts and the current situation, and acts to change the situation towards a design goal. Although theories of human cognitive process provide an analogical foundation for the construction of a framework of the mechanism of the agent, there is no claim that the mechanism is a model of a cognitive process.

A situated design agent is composed of processes to retrieve the values of exogenous and autogenous variables, to change those variables, and processes and “memories” to couple the two classes of processes. Exogenous variables and autogenous variables refer to the variables that
describe a design environment and the variables inside an agent, respectively. A situated design agent demonstrates the following characteristics:

- to define a provisional design goal under a given design problem,
- to perform actions directed by the provisional goal defined by itself,
- to be able to have expectations about the situation brought about actions,
- to construct a situation on the basis of currently focused concepts,
- to evaluate if the situation belongs to the provisional goal and if the goal is actually a solution of the design problem,
- to be able to change the focuses of concepts or to revise concepts so as to respond to unexpected situations,
- to elaborate the provisional design goal on the basis of the current situation and currently focused concepts, and
- to perform consequential goal-directed actions.

2.3 INTERNAL PROCESSES OF A SITUATED DESIGN AGENT

The framework of the internal process of the situated design agent has been being constructed by some thought experiments and analogy to human cognitive processes that couple sensation, perception, conception, and action. The internal processes of a situated design agent are classified into five different categories. The classes of processes are:

- sensation
- perception
- conception
- action
- memory construction and management.

Sensation is the process of transforming changes in the exogenous variables and autogenous variables, based on both sense-data and activated percepts and concepts, into the lowest level of description of the changes, i.e., sensory experiences. Sensation is performed as a parallel process. It is driven partly but the sense-data and partly by the activated percepts that structure sense-data. Perception is the process of transforming the changes in the sensory experiences into the changes in the percepts, based on both activated concepts and sensory experience, and structuring the current percepts on the basis of the immediately antecedent percepts and the changes in the percepts. Perception is parallel in the sense that it is driven by both sensory experiences and expected percepts. Conception is the process of transforming the changes in the percepts into the changes in the concepts and structuring the current concepts on the basis of the immediately antecedent concepts and the changes in the concepts. Perception and conception are
performed recursively until the percepts and the concepts converge to produce a situation. They involve two classes of sub-processes, i.e., hypothesizing and expectation. Hypothesizing is the process of finding a portion of concepts that supports the consistency of the current percepts and expected percepts. Expectation is the process of forming a collection of possible percepts. Action is the process of changing a state of some of exogenous and autogenous variables. Memory construction and management is the process of constructing, retrieving, and introspecting memories of structured history of a state of affairs and a course of events described by the exogenous and autogenous variables. A portion of autogenous variables describes such a memory. Therefore, the memory does not store meaning for an agent. A portion of concepts that an agent forms represents the interpretation of the memory by the agent.

3. Retrospective Discourse Analysis
The findings in analyses of an architect’s discourse explaining an actual process of designing a certain house are described. A retrospective discourse, in which an architect explains a process of designing a residential house, is being analyzed. The goals of the discourse analysis are to find the significant patterns of the interactions between architect’s action and the situation the architect faces, to represent the principal cognitive processes behind the interactions, and to derive the requirements to build the framework of a situated design agent on the basis of the representation.

3.1 METHODOLOGY AND LIMITATION
A retrospective discourse uttered by an architect is employed as data to acquire information about a design process of an actual house. Since the author focuses on the events in a process of designing, such as thought, concept formation, intention, etc., behind a course of actions in a design process, the author requested the architect to describe what he did in the temporal order. The architect described them by indicating, in the temporal order of production, the external representations produced in the design process, such as sketches, three-dimensional models, and drawings. Here, it is assumed that the temporal order of presentation of the external representation is almost equivalent to the temporal order of the events in the design process. However, it has to be mentioned that the retrospective discourse could be biased by the mental state of the speaker looking back the past events. To avoid this problem, a protocol analysis is often used to acquire a discourse from which the speaker’s cognitive process is excerpted. The protocol analysis requires the speaker
to think loud while he or she is performing a given task. A design process of an actual building is too long to record everything.

3.2 THE DISCOURSE
One discourse, in which an architect describes his process of designing a certain residential house, is videotaped from two angles to focus on the whole actions performed by the architect as well as the use of the external representation in the explanation. The house will be built in a residential area in Tokyo. The discourse has the length of approximately two hours. In the discourse, the architect explains, retrospectively but in accordance with progress of the design, what have been performed, thought, formulated, synthesized, prospected, analyzed, evaluated, and found in the design process. All of the external representations, such as sketches, models, and drawings produced in the design process, are used in the explanation.

3.3 ANALYSES
The outlines of the current findings are described here. A surprising pattern of actions or a qualitative pattern is not found at this point since the discourse is under analysis.

The reason why only the outlines are described is that since the current discourse is taken from a single architect’s work on a single house the data is not enough to assure the universality and the rigor of the analysis and the outlines might be more informative for the creation of a design agent than analysis.

Analysis I
The first analysis focuses on the structure of the design process as the process of either problem solving or explore. It is being investigated how and when in the design process the formulation, articulation, and reformulation of the design problems, the synthesis, sophistication, and modification of the structure of design solutions, the analysis of the behavior of the solutions, and the evaluation of the performance and quality to be provided by the design solution occur.

The naive findings so far are the followings. All of the design problems are not formulated and focused on at once. The architect intentionally focuses on a few problems and tries to solve them. Some design solutions derive another problem and some design solutions solve another problem by chance. Some situations confirm the architect that certain strategies should be employed and other situations make the architect give up a certain type of design solutions. The design process can be divided into major two stages with respect to the issued focused in
designing. One is design paradigm formulation stage and the other is design explore stage. The former is antecedent to the latter. It should be mentioned that the stages are not perfectly separated from each other in the sense that some actions seen as paradigm formulation could be also observed in the design paradigm formulation stage. The architect advances the design not only in a depth-first search manner but also in a width-first search manner.

In the design paradigm formulation stage, the architect tries to formulate some problems that the architect is required, by the client or the building codes, or recommended, by the client or himself, to solve. The architect formulates some paradigms to derive the strategies to solve the problems by synthesizing a set of prospective solutions to a limited problems. A first solution search is not necessarily adopted. Sometimes, better solutions are sought. Width-first searches tend to be performed in this stage in the design process. The WFS’s seen in the empirical data is limited in two senses. The problem, which is set to be solved by the search, is only a portion of a set of all problems that should be solved. The set of solutions, each of which is generated to be verified if it is really a solution, are only a portion of a set of all solutions. The architect seems to limit the problems and solutions intentionally or intuitively.

In the design explore stage, the architect tries to find, under the paradigms by the architects, a solution to the problems formulated in the design paradigm formulation stage. This stage is explore in the sense that a solution let the architect find the problem, task, or paradigm that have not been apparent before and the architect sophisticates the solution by synthesizing a solution to the re-formulated problems.

Analysis II

The second analysis focuses on the relation among the intentions of the architect and the actions performed by the architect. It is being investigated how the intentions are fulfilled or not fulfilled. It is supposed, behind this analysis, that designing is a goal-directed activity mainly composed of purposive actions.

A finding so far is that not all actions are purposive. Some actions seem to be causally performed in certain situations even though there are alternative actions. The actions are not purposively planed as the result of a means-ends analysis. It seems that the architect cannot help performing a certain action in a certain situation. On the other hand, some purposive actions are performed without a certain goal even though they are intentional. In a rational explanation of a design process, it is said that a designer synthesizes a structure with the expectation that the structure should have the potential to bring about the behavior, which
would be the measure of the function desired to be provided by the structure, and that the theoretical, either qualitative or quantitative, belief or knowledge facilitates the designer to perform a certain action. In addition, the empirical data shows that the architect often synthesizes a set of solution with an opportunistic expectation that something rather than an approved solution should be found.

**Analysis III**
The third analysis focuses on the cognitive process of the architect. The interactions among what the architect knows, sees, thinks, imagines, and expects are being investigated. The external representations are not only the depictions of the structure of a design product but also the indices associated with apparent or latent concepts with which the design solution is synthesized, analyzed, or evaluated.

The findings are the followings. The architect occasionally comes up with some concepts that dominate the subsequent process. Sometimes, the architect hypothesizes something before making the external representations and tries to verify the hypothesis. Sometimes, the architect makes the external representations just to know if a certain proposition hold or not in the design solution. It is expected to find some clues to the representation of the internal mechanism of a situated design agent’s forming a set of domain or project specific concepts during the design process.

**4. Implications: Situatedness and Knowledge in Designing**
The concept of situatedness may bridge the contradictory characteristics in a process of designing, i.e., rationality and creativity. The rationality plays an important role in designing by navigating purposive actions in designing towards a good design solution. The creativity plays an important role by letting a designer come up with an unexpected but bright design solution that is not necessarily a result of rational derivation from the initial state of a design process. This Section aims to give a viewpoint of explanation why the concept bridges the rationality and the creativity rather than a clear answer to the issue.

**4.1 SITUATION AND KNOWLEDGE**
It is assumed that the content of what a human perceives is an appreciation of a product of transactional processes of associating the human with the environment. The author employs the notion of situation to refer to such an internal representation. The notion of situation refers to an agent’s understanding of the current relation between the agent and its external and internal environment. A situation
may not be a direct projection of an environment, an internal state of a human, or their relationships (Gero and Fujii 2000; Fujii and Gero 2000), but is perceived on the basis of a part of internal state of an agent, which is formed through the history of situations and transactions, and an environment. It is not sure that the thing independent from the appreciation, but what we should keep in our mind is that a human, from his/her point of view, interacts not with the things independent from the appreciation but with situations. In this sense, everything a human does is situated and so is designing. In designing, a designer is exposed to individuals and the relationships among them rather than the abstraction of the individuals and the relations.

A process of designing is composed of actions. All actions are, by definition, situated. A designer continuously interacts with situations. Through the interactions with situations, a human may construct a certain kind of memories on the basis of a history of the situations. An appreciation of the memories may be the personal or private understandings concerning a world. The potions of the memories may be unconscious or tacit understandings. They don’t necessarily have to be abstraction of the history like explicit knowledge. An experienced designer would have such kinds of understandings through practices in designing, but explicitly represented knowledge may not express them because of its nature.

Knowledge helps a designer to make rational decisions in designing. A designer can derive the behaviors of an artifact from its structure on the basis of so called scientific theories. Knowledge is also employed to hypothesize the applicable moves to synthesize the structure of an artifact that is expected to provide a preferred situation, to articulate a preferred situation in terms of functions, to hypothesize and behaviors to provide expected functions, and so on. Logical inference on the basis of explicit and public knowledge does not necessarily derive these hypotheses and articulation. If knowledge can derive every structure, behavior, function, and move for the synthesis of a structure, there would be no room for creative designing. Understandings that are not represented as knowledge complements knowledge and helps a designer to find better moves that are never derived by logical inference. These phenomena should be one of the significance of situatedness in designing.

4.2 SITUATION AND PRACTICAL RATIONALITY

It is not only the limitation of representation of understandings about situations in designing but also the limitation of the resources that a designer can use in each situation in a practice of designing that let us see the significance of situatedness in designing.
A design is a purposive activity towards a preferred situation. Actions in designing, from a macroscopic point of view, are purposive and rational in the sense that they are performed on the basis of the result of deliberations about what course of actions the designer ought to take or are constrained by the result. However, because of the limited resource employed for the deliberation (Bratman 1987) and the economy of the representation of a course of actions, i.e., a plan (Suchman 1987), it is rare that all instances of actions composing a course of actions towards a design goal are planned. Instead, a situation in a process of designing enables a designer to choose and perform a concrete action applicable in the situation. In addition, since the concrete action could not be planned unless a designer really faces a situation, some actions actually chosen are unexpected ones and are performed to find an unexpected result. When a designer faces an unexpected result, the designer would try to understand the result by re-appreciating it and performs the succeeding actions in accordance with a new situation perceived through the new appreciation (Schon 1983).

Situated actions enable a process of designing to maintain the rationality in not an ideal but a practical way. It is impossible for a human designer to enumerate all candidates, such as prospected structures, expected behaviors and functions, applicable moves towards a goal, and to select the most desirable one among them if the numbers of candidate are more than countable infinity. Therefore, even if we have enough knowledge to enumerate all candidates in designing, it is seldom for the best candidate to be selected rationally by enumeration of the candidates, analysis and evaluation of each candidate.

4.3 WHAT A SITUATED DESIGN AGENT MIGHT ENTAIL

In the situated design agent approach, a process of designing would be extracted from observation of a state of affairs and a course of events produced through the interaction between a situated design agent and a design environment where the agent works. The situated design agent is expected to produce a course of actions that corresponds to the observations and findings described above so that it would be verified that the framework of the internal process of the design agent, which is shown later, is consistent with an actual process of architectural designing. A mechanism by which the hybrid search between DFS and WFS is enabled and another mechanism by which an action is performed in a purposive manner as well as in a quasi-causal manner should be investigated. Intuitively speaking, a non-equivalent interrelation between a process that physically couples sensation and action and another process that logically couples perception and action on the basis of the concepts,
which is currently focused, is assumed to be such a mechanism. The former process is a mathematical structure that would be a model of a logical expression employed in the latter process. The interrelation between the two processes is so called an interpretation that is fluid and flexible enough to render the logical expression true as possible. The two processes are also fluid enough to be modified to make the interpretation plausible.

The followings are some of the situations and patterns of situated actions representing the characteristics in a process of designing. The important things are that not all portion of knowledge, complete knowledge, but the hypothesized portion of knowledge is employed and that each situation complements the hypotheses and triggers the change in the hypotheses. If all the characteristic sub-processes in designing require exhaustive enumeration of the possibilities and their evaluation, a designer has to enumerate infinite numbers of the possibilities and evaluate each of them, forever. Our situated agent approach is seeking the organization of the sub-processes with which a design agent demonstrates the patterns.

• A design agent may define a provisional design goal under a given design problem. Even if the problem were ill-defined, a goal would be defined on the basis of some hypotheses complementing the ill-formed definition. The hypotheses are not necessarily chosen by deliberation employing all contents of knowledge. The choice of hypotheses is neither a result of an arbitrary process nor the result of a best answer search. Because of the complexity of designing of an artifact, achieving one goal may conflict with achieving another. The hypotheses chosen may arbitrate among the conflicting goals.

• A design agent may select an action, which the agent believes efficient one to achieve a goal, and have expectations about the situation brought about by actions. The selection and expectation are on the basis of not complete knowledge but current the hypotheses. It would not be the case that the result and consequences of each action are derived based not on all knowledge, which a designer has, but on some portion of knowledge that are consistent with the hypotheses.

• A design agent may change or revise the hypotheses so as to respond to unexpected situations and to maintain the consistency between the hypotheses and the current situation by re-appreciation. Once the change happens, a design agent may elaborate the provisional design goal on the basis of the current situation and newly formulated hypotheses.

In these situations, the understanding that cannot be represented explicitly in a symbol system of the situations is employed to
complement hypotheses – a portion of complete knowledge. In the case where the theoretically rational conclusion cannot be derived in a deterministic way, situated actions play a significant role to maintain practical rationality in designing as well as to give a designer an opportunity to find something unexpected unless facing the situation.

4.4 MEMORY CONSTRUCTION AND CONCEPT FORMATION

   It is claimed that the flexibility of memory construction and concept formation enables a situated design agent to demonstrate some characteristics associated with designing. The following are relations between the internal processes of a situated design agent and the characteristics that the agent demonstrates:

   • Concepts, in general, have the potential to associate something with other things. In designing the world can be defined in terms of relationships between function, behavior and structure. The agent could define a provisional design goal in terms of behaviors and structures under a design problem given in terms of functions.

   • The process of expectation has the potential to associate, on the basis of some of the concepts, a course of actions with its result and consequences.

   • A focused part of concepts could be an interpretation of a collection of sensory experiences, percepts, and memories. The process of perception is affected by the focused concepts and the process of sensation is affected by percepts. The memories are constantly reconstructed through these processes. When the current interpretation is not consistent with the current sensory experiences, percepts, or memories, the process of hypothesizing may change the interpretations. These processes let a situated design agent perform courses of actions that could be observed as change of the focuses of concepts, revision of concepts to respond to unexpected situations, or construction of a situation on the basis of currently focused concepts.

   • Once a focused part of concepts has changed, the design problem, the provisional goal, the actions to achieve the goal, and expectations, which were defined or planned with respect to the old part of concepts, would be redefined or planned on the basis of the new part of concepts. These processes let a situated design agent produce a course of actions that could be interpreted as situated actions in designing.
5. Future Directions and Conclusions

The retrospective discourse mentioned above is still being analyzed. The author plans to continue the analysis with the expectation that a surprising pattern in designing would be discovered. In addition, other discourses concerning other projects done by other project have to be analyzed for the universality of the finding in architectural design processes. On the other hand, the bridges between the empirical findings and the computational model of the internal process of a situated design agent.

This paper described a situated design agent approach to understand and explain the characteristic nature in architectural design and showed some findings in retrospective discourse analyses about a design process of a real house as an empirical basis to discuss the feasibility of the situated design agent approach. Some implications for the development of a situated design agent are also explained.

References