Relationship between affordance and dementia care

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Dementia is the progressive decline in cognitive function due to damage or disease in the body beyond what might be expected from normal aging. Dementia persons cannot reasonably live their lives. In order to support dementia persons' lives, various approaches are proposed. Bozeat and Hodges showed affordance might give a certain support to (semantic) dementia persons of understanding (meanings of) objects. In this paper, based on the concept of affordance, abduction, and chance discovery, a relationship between dementia care and affordance is discussed.

1. Introduction

Because of the advanced and innovative medical treatment, we are able to live much longer than 40 or some years ago. It will be happy for us to live long, but the other problems are caused by such long lives. One of the most famous problems is increasing patients who are suffered from cancer. It will be able to be overcome by the advancement of medical treatment and is a problem for individuals. Furthermore serious problem for a person and even for his/her family and surroundings will be dementia. It is the progressive decline in cognitive function due to damage or disease in the body beyond what might be expected from normal aging. Dementia persons cannot reasonably live their lives. It is said that the current medical treatment cannot cure dementia completely. Even in the near future, it will be negative to cure dementia. Dementia is caused by problems in a brain. Accordingly, it is more difficult to cure dementia than cancer. Currently, some methods to delay the progress of dementia are proposed. For instance, a therapy room or house will be one of the solution to take care of dementia person [Sloane, 2002]. Actually, it is rather a support system for dementia person's everyday life.

In addition, several researches and experiments are conducted to analyze the feature of dementia. Bozeat and Hodges showed affordance might give a certain support to (semantic) dementia persons of understanding (meanings of) objects [Bozeat, 2002, Hodges, 2000]. Actually, it covers a limited situation, but it would be better to introduce a concept of affordance to a dementia care. Affordance has been discussed in Artificial Intelligence or philosophy as well as in cognitive science. For instance, Magnani discussed manipulation of affordances in the abduction framework [Magnani, 2010]. Thus strategies for dementia care can be discussed and built in the framework of affordance theory. Affordance theory is a natural processing in actual environments. In addition, affordance can be dealt with abduction framework and since affordance is not explicitly displayed but hidden in the environments. Accordingly, chance discovery [Ohsawa and McBurney, 2003] can be one of the

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strategies to a dementia care problems.

In this paper, based on the above discussion, a dementia care under the concept of affordance, abduction, and chance discovery is discussed.

2. Abduction, Chance discovery

2.1 Abduction (hypothetical reasoning

According to the definition by Peirce, abduction is characterized as follows [Peirce, 1955]:

> Abduction is an operation for adopting an explanatory hypothesis, which is subject to certain conditions, and that in pure abduction, there can never be justification for accepting the hypothesis other than through interrogation.

Abduction is very powerful in the human reasoning. For the computation, abduction is usually used to find the reason (set of hypotheses) in a logical way to explain an observation. The original abduction is rather complicated reasoning system. For the computation a certain restriction such as selecting hypotheses from a hypothesis base is usually given. For instance, the inference mechanism of Theorist [Poole, 1987] that explains an observation (O) by a consistent and minimal hypotheses set (h) selected from a set of hypotheses (H) is shown as followings.

$$F \nvdash O. \qquad (O \text{ can not be explained by only } F.) \tag{1}$$

$$F \cup h \vdash O. \qquad (O \text{ can be explained by } F \text{ and } h.) \tag{2}$$

$$F \cup h \nvdash \Box. \qquad (F \text{ and } h \text{ is consistent.}) \tag{3}$$

Where F is a fact (background knowledge) and $\Box$ is an empty clause. A hypothesis set (h) is selected from a hypothesis base ($h \in H$).

Thus, "reason" is usually selected from the knowledge (hypotheses) base. For instance, when Theorist is used for an LSI circuit design, F includes knowledge about the devices' function and their connections, and the knowledge of other rules. In addition, H includes candidate devices and their candidate connections. If the relation between input

and output of the circuit is given as an observation O, Theorist computes the name of devices and their connections as hypotheses h. Therefore, usual abduction requires a perfect hypotheses base from which a consistent hypotheses set is selected to explain an observation. Here, "perfect hypotheses base" means the hypotheses base that contains all the necessary hypotheses.

2.2 Chance discovery

Chance Discovery is a discovery of chance, rather than discovery by chance. Ohsawa defined chance (risk) as "*a novel or rare event/situation that can be conceived as either an opportunity or a risk in the future* [Ohsawa and McBurney, 2003]". It is naturally understood that a chance, which is either known or unknown, includes possibilities to cause unfamiliar observations. It can also be said that a chance is an alarm like an inflation of money supply or a big difference between future (estimated, reserved) and current stock prices that will change the middle or long term economic situation (Japan, in 1990). We sometimes ignore such critical factors, because we cannot understand that they are important factors. This is because the results or the factors are exceptions, and rare or novel events.

Chance discovery is also characterized as an explanatory reasoning, however since "chance" is defined as unknown hypotheses, some techniques to deal with an empty or an imperfect hypotheses base are required. If so, such an inference mechanism as usual abduction (hypothetical reasoning etc.) is not sufficient to achieve chance discovery. Chance discovery needs an explanatory reasoning that can deal with an empty or imperfect hypotheses base.

Therefore, I have previously characterized chance discovery as an explanatory reasoning for the unknown or unfamiliar observations, then defined "chance" as follow:

Definition 1 *1. **Chance** is a set of unknown hypotheses. Therefore, explanation of an observation is not influenced by it. Accordingly, a possible observation that should be explained cannot be explained. In this case, a hypotheses base or a knowledge base lacks necessary hypotheses. Therefore, it is necessary to generate missing hypotheses. Missing hypotheses are characterized as chance.*

*2. **Chance** itself is a set of known facts, but it is unknown how to use them to explain an observation. That is, a certain set of rules is missing. Accordingly, an observation cannot be explained by the facts. Since rules are usually generated by inductive ways, rules that are different from the trend cannot be generated. In this case, rules are generated by abductive methods, so trends are not considered. Abductively generated rules are characterized as chance.*

In fact, chance has a flavour of probabilistic reasoning, however, this definition does not represent a chance in an explicit probabilistic form. Instead, this definition treats chance in a logical way. This is because a logical inference, especially abduction, seems to be a powerful weapon to perform a chance discovery that is an explanatory reasoning.

3. Affordance

Gibson ecologically introduced the concept of affordance for perceptional phenomena [Gibson, 1977, Gibson, 1979]. It emphasizes the environmental information available in extended spatial and temporal pattern in optic arrays, for guiding the behaviors of animals, and for specifying ecological events. Thus he defined the affordance of something as "a specific combination of the properties of its substance and its surfaces taken with reference to an animal." For instance, the affordance of climbing a stair step in a bipedal fashion has been described in terms of the height of a stair riser taken with reference to a person's leg length [Warren, 1984]. That is, if a stair riser is less than 88% of a person's leg length, then that means that the person can climb that stair. On the other hand, if a stair riser is greater than 88% of the person's leg length, then that means that the person cannot climb that stair, at least not in a bipedal fashion. For that Jones pointed out that "it should be noted also that this is true regardless of whether the person is aware of the relation between his or her leg length and the stair riser's height, which suggests further that the meaning is not internally constructed and stored but rather is inherent in the person's environment system" [Jones, 2003].

In the context of human-machine interaction Norman extended the concept of affordance from Gibson's definition. He pointed our that "...the term affordance refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used. [...] Affordances provide strong clues to the operations of things. Plates are for pushing. Knobs are for turning. Slots are for inserting things into. Balls are for throwing or bouncing. When affordances are taken advantage of, the user knows what to do just by looking: no picture, label, or instruction needed" [Norman, 1988]. Thus Norman defined affordance as something of both actual and perceivable properties. Accordingly his interpretation has effectively been introduced to interaction designs.

Zhang categorized several types of affordance into the following categories [Zhang, 2006]:

- Biological Affordance

  For instance, a healthy mushroom affords nutrition, while a toxic mushroom affords dying.

- Physical Affordance

  For instance, the flat horizontal panel on a door can only be pushed. Many of this type of affordances can be found in Norman [Norman, 1988].

- Perceptual Affordance

  In this category, affordances are mainly provided by spatial mappings. For instance, if the switches of the stovetop burners have the same spatial layout as the burners themselves, the switches provide affordances for controlling the burners. Examples of this type

include the pictorial signs for ladies' and men's re-strooms.

- Cognitive Affordance

  Affordances of this type are provided by cultural conventions. For instance, for traffic lights, red means "stop," yellow means "prepare to stop," and green means "go."

- Mixed Affordance

  For instance, a mailbox, which is one of the examples used by Gibson, does not provide the affordance of mailing letters at all for a person who has no knowledge about postal systems. In this case, internal knowledge is involved in constructing the affordance in a great degree.

Thus since Gibson's introduction, affordance has been widely discussed, and the other perspective and extensions have been added. Especially, it has been effectively introduced to interface designs after several extensions.

4. Dementia

Dementia is the progressive decline in cognitive function, such as memory, attention, language, and problem solving, due to damage or disease in the body beyond what might be expected from normal aging. In the later stages, dementia persons will not be able to recognize time (day of the week, day of the month, and year etc.), place, and person. Phenomena due to aging and dementia are different. For instance, for memory, aged person does not forget all of his/her experiences, on the other hand, dementia person forgets whole of his/her experiences. Dementia is roughly categorized to cortical and subcortical. For instance, several types of cortical dementia are reported such as Alzheimer's disease. Except for the treatable types, there is no cure to dementia, although scientists are progressing in making a type of medication that will slow down the process. For instance, For the medication of Alzheimer, actions such as cheerful communication and proper stimulation are recommend [Kasama, 1997]. For instance, some studies have found that music therapy which stimulates emotion as well as brain may be useful in helping patients with dementia [Aldridge, 2000]. Alternative therapies are also discussed for the care of Alzheimer's disease and dementia [Cafalu, 2005a, Cafalu, 2005b].

Bozeat and Hodges analyzed the feature of mapping between objects and their meaning for semantic dementia person from four factors — affordance, presence of recipient, familiarity, and problem solving [Bozeat, 2002, Hodges, 2000]. They showed very interesting results For instance, they pointed out "as a group, the patients did not achieve better performance on a subset of affordable objects when use of these was compared with a familiarity-matched subset of objects lacking such affordances. This absence of a general group benefit applied both to overall use and to the specific component of use afforded by the

object's structure.[...]it became clear that there was a reliable benefit of affordance on the specific components of use, but only for the most impaired patients." They also pointed out "The impact of recipient, like affordance, was found to be modulated by the degree of semantic impairment. The patients with a moderate level of conceptual impairment demonstrated significantly better use with the recipient present, whereas the patients with mild and severe impairment showed no effect. [...] It was not surprising, therefore, to find that familiarity also influenced performance on object use assessments."

These observations and analyses show that proper affordance might give a certain support to dementia persons understanding (meanings of) objects.

5. Dementia care inspired by affordance

It is not possible to prepare all necessary things in every places. Sometimes an alternative or an extended usage of things will be necessary. For a proper and an extended usage of a thing, it is necessary to present proper information of it. At least, it is necessary to suggest such information. Sometimes it can be presented as a memorandum or a sign. In the other case, it can be received as hidden information inside of the thing. Actually it is not always necessary to provide such hidden information. For a progressive and promising system, it is not realistic to prepare all the necessary information to things. Sometimes such information is not correct and will change in the future. For instance, it is ridiculous to attach a sign such as "You can sit here." to tree stumps. It is rather realistic to suggest information about its hidden functions.

In this section we discuss how to present such hidden information in dementia care situation. Such hidden information can be presented as certain stimuli in such situations. Because, as shown in the previous section, even for dementia person, if he/she receives certain stimuli, he/she sometimes achieve better performance. The problem is that what type of stimulus will be better to present and how to make it recognize. Actually such stimulus should be "afforded (selected from an environment)" by the user. That is, it can be regarded as an "affordance" in an environment. Accordingly we introduce concept of affordance to a dementia care system. Proper affordance might give a certain support to dementia persons understanding (meanings of) objects. Thus affordance is a fruitful concept for recognizing objects and using them as tools. According to Gibson's definition, affordance is hidden in the nature and it should be accepted by us naturally. For instance, if an object's upper side is flat and it has a certain height, the observer will be able to afford it as something to sit, rest or sleep. Of course, the level of affordance will be change according to observer's acceptance ability. For a certain person a tree stump will function as a chair, but for the other person it will not. If they are able to regard a tree stump as a chair, it will be necessary to provide a proper guidance to discover an affordance as a something to sit.

For normal persons, it is not so difficult to provide such guidances. They can also understand analogy, so that they can extend the meaning to the other materials. For instance, after finding that a tree stump functions as a chair, they can also understand a wooden board or box can also function as a chair. That is, they can extend or map the meaning to the other situations. However, for dementia persons, it is not easy to provide a proper guidance with which they can afford the function of an object. Actually, for person who does not have common knowledge or context, it is also not easy to provide a proper guidance for affordance discovery. For them affordance is something rare or novel. Accordingly, it is rather difficult to be aware of "affordance" as an afforded matter. In therapy houses, there should be many things which are not able to properly used by dementia persons. In the case, it is necessary to provide certain guidance to lead the user to the correct direction to use things properly. The simplest method will be to attach the name and usage of things. It will functions well for normal persons. However, for impaired persons, sometimes even such attachment will not function well. For them, it will be necessary to apply the other strategy to suggest or instruct the meaning or usage of things. For semantic dementia persons, it is observed that they did not achieve better performance on a subset of affordable objects when use of these was compared with a familiarity-matched subset of objects lacking such affordances. Therefore, when we design an environment for dementia persons, it is necessary to consider such unhappy situations. It is necessary to prepare specialized affordances to dementia person. Even if they can detect affordance, they might not understand what it will emerge.

For affordance, according to the Gibson's definition, an *Object* is observed and affordance is detected in the environment to understand its meaning. Then, when meaning is fixed, by using abduction framework, the affordance determination situation will be logically described as follows:

$$F \cup affordance \models Object \qquad (4)$$

$$F \cup affordance \not\models \Box \qquad (5)$$

The above is described based on the formalization of Theorist [Poole, 1987]. F is so called facts which involves fundamental knowledge in the world. The obtained affordance is consistent with F (equation (5)) and gives life (meaning) to the *Object*. Thus *Object* involves invisible *meaning* and by adopting discovered affordance, potential meaning appears. Therefore, in the above formalization, *meaning* does not appear explicitly.

However, in the above application, we would like to give a certain meaning to the *Object* explicitly. Though meaning exists inside of the *Object*, in this framework meaning is explicitly described. That is, meaning should be observed and affordance functions as a type of link to *Objects*. When meaning is fixed, the affordance determination situation will be logically described as follows:

$$Object \cup affordance \models meaning \qquad (6)$$

$$Object \cup affordance \not\models \Box \qquad (7)$$

That is, affordance can be regarded as a hypothesis. We can select consistent affordance (equation (7)) in the environment (hypothesis base) to explain meaning. In addition, for understanding subset of or similar afforded objects ($Object'$), the affordance determination situation will be logically described as follows:

$$Object \cup Object' \cup M \cup affordance \models meaning \qquad (8)$$

In fact, the above description is based on Goebel's formalization of analogy [Goebel, 1989]. M is a mapping function from $Object$ to $Object'$. That is, to understand the same meaning of the subset of or similar afforded objects, an additional mapping function M is required. Thus if M can be determined and the usage of $Object$ is known, $Object'$ can also be understood. In fact, for normal persons, M is easy to understand. However, for dementia persons, it is pointed out that it is rather difficult to understand and determine M. Then the issue becomes how to suggest a mapping function M as an additional hypothesis. For typical analogical mapping, objects in the source domain and the target domain are quite different. In fact, the typical analogical mapping is determined based on conceptual structure as pointed out by Gentner [Gentner, 1983, Gentner, 1988, Gentner, 1989]. For instance, if we know about the water flow system where water flows from a place with greater pressure to a place with less pressure, we can guess or find the heat flow system where heat flows from a place with greater temperature to a place with less temperature. However, for the applications shown in this paper, a mapping function will not be so complex as typical analogical mapping. For the proposed application, expected situations are very simple. For instance, to give a hint (mapping function) of sitting on a wooden box to dementia person who could use a tree stump as a chair. In fact, the situation is generally structured, but for an application, we can only focus on an aspect such that the upper side is flat. This type of mapping will be one dimensional mapping and not so confusing. Thus theoretically a mapping function becomes simple. The above logical descriptions can be illustrated in Fig. 1.

$affordance(\text{furniture}) \longleftarrow - - - - - \quad - - - - - \longrightarrow affordance(\text{sit})$

$$\Downarrow M$$

$affordance(\text{plant}) \longleftarrow - - - - - \quad - - - - - \longrightarrow affordance(\text{sit})$
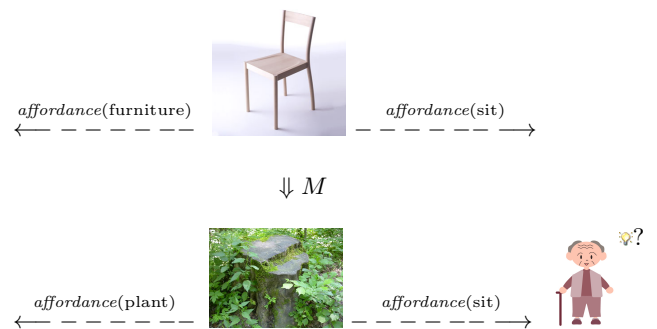
Figure 1: Affordance: communication between human and environment

At last, the most important issue is how to suggest hidden

information as affordance. An answer will be given in the following sections.

6. Information offering to dementia persons

6.1 Information offering strategies for dementia persons

In Section 5., based on abduction, I reviewed the formalized concept of affordance based support system for dementia persons. In the formalizaion the most important relationship between an object and meaning is the last equation shown in Section 5.. I review the equation below:

$$Object \cup Object' \cup M \cup affordance \models meaning \qquad (9)$$

M is a mapping function [Goebel, 1989] from $Object$ to $Object'$. That is, to understand the same meaning of the subset of or similar afforded objects, an additional mapping function M is required. Thus if M can be determined and the usage of $Object$ is known, $Object'$ can also be understood. In fact, for normal persons, M is easy to understand. However, for dementia persons, it is pointed out that it is rather difficult to understand and determine M. From the viewpoint of communication, if someone cannot understand or obtain the meaning of an object, it means that a communication link is missing between the object and the person and he/she cannot obtain any proper affordance given in the environment. In that case he/she needs certain hints to be aware of such affordance.

Thus the final issue is how to suggest hidden information as affordance. This type of information is usually hidden in the environment. Thus the proposed type of application can be discussed under the context of chance discovery. As I mentioned, chance discovery can be performed by a combination of abduction and analogy. Also as Magnani pointed out, affordance can be performed by a certain type of abduction. In the above, the concept of affordance is also described in the framework of Theorist that is hypothetical reasoning (limited version of abduction). Accordingly, all procedures can be described in abduction's framework. In addition, it is happy for us that we can simplify our problems to one dimensional mapping. Of course, in this section, for the first step, a very simple case is discussed. For the actual usage, much more complex situation should be considered. My assumption is that such complex situation can be transformed to a combination of simple situations. To deal with complex situations, it is necessary to develop a mechanism to transform complex situation to a combination of simple situations such as polynomial. Anyway, for such systems, chance discovery based curatorial strategies shown below should be introduced to offer understandable mapping suggestion.

6.2 Curation

There is at least a person who is responsible as "curator" in (special) exhibitions, galleries, archive, or (art) museums. Their main task is a curatorial task, which is multifaceted.

Curator comes from a Latin word "cura" which means cure. Then originally it used for a person who take care of a cultural heritage.

In the report by American Association of Museums Curators Committee (AAMCC) [AAMCC, 2009], they pointed out "curators are highly knowledgeable, experienced, or educated in a discipline relevant to the museum's purpose or mission. Curatorial roles and responsibilities vary widely within the museum community and within the museum itself, and may also be fulfilled by staff members with other titles." Then they showed the definition of curator as follows;

- Remain current in the scholarly developments within their field(s); conduct original research and develop new scholarship that contributes to the advancement of the body of knowledge within their field(s) and within the museum profession as a whole.

- Make recommendations for acquiring and deaccessioning objects in the museum collection.

- Assume responsibility for the overall care and development of the collection, which may include artifacts, fine art, specimens, historic structures, and intellectual property.

- Advocate for and participate in the formulation of institutional policies and procedures for the care of the collection that are based on accepted professional standards and best practices as defined by AAM, CurCom, and other relevant professional organizations.

- Perform research to identify materials in the collection and to document their history.

- Interpret the objects belonging or loaned to the museum.

- Develop and organize exhibitions.

- Contribute to programs and educational materials.

- Advocate and provide for public use of the collection.

- Develop or contribute to monographs, essays, research papers, and other products of original thought.

- Represent their institution in the media, at public gatherings, and at professional conferences and seminars.

- Remain current on all state, national, and international laws as they pertain to objects in the museum collection.

Thus curators have responsibilities for various aspects of exhibition activities. However, the most important activity will be a plan of exhibition. For that the above activities such as research, interpretation and acquisition are necessary. They should properly exhibit a truth which is result of their researches and interpretations.

Based on the the above definition of curation, I defined curation in chance discovery [Abe, 2010] (An extended definition was given in [Abe, 2011, Abe, 2012]).

- Curation is a task to offer users opportunities to discover chances.

- Curation should be conducted with considering implicit and potential possibilities.

- Chances should not be explicitly displayed to users.

- However, such chances should rather easily be discovered and arranged according to the user's interests and situations.

- There should be a certain freedom for user to arrange chances.

By the introduction of the concept of curation, offerring understandable mapping suggestion can be achieved.

6.3 Shikake?

In [Abe, 2013], I discussed the role of shikake in chance discovery. According to Matsumura's definition[Matsumura, 2012], a shikake is a trigger to start a certain action or to change person's mind and behaviour. As a result of the action, all or part of problem will be solved. It sometimes is not the person's will. Thus as shikakeology, such operation should be conducted implicitly. As an example of (implicit) shikake, I illustrated the following example:

> An example of an implicit shikake is, for instance, hidden Mickey (Fig. 2) in the Disney Land. In order to discover the hidden Mickey, people run around the Disney Land. During searching, they may discover the other interesting things. Of course, when they can find the hidden Mickey, they will be happy. Thus hidden character functions as a trigger to such activities (search and run). By this trigger (shikake), they can enjoy the Disney Land more than a simple tour in the Disney Land.
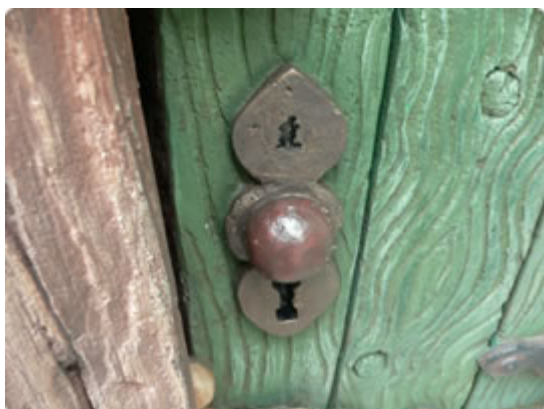

Figure 2: Hidden Mickey

Matsumura continues that shikake should be properly designed. That is, the relationship between a problem to solve and a trigger to action should be properly designed.

In addition, Matsumura uses a keyword "affordance" to explain such trigger. Actually Matsumura distinguish psychological design from material design, but I think it can be discussed together.

In [Abe, 2013], I compared a chance and a shikake in the framework of affordance. Actually a shikake is a trigger and chance is an event or a situation. That is, a trigger will introduce us to an event or a situation. Thus a shikake can be a trigger to discover a chance. In addition, I showed the chance discovery scheme can be explained by curation. A shikake can be a trigger in curation. And a shikake can also be explained by affordandce. By introducing a shikake to affordance-based chance discovery, more proper selection of affordance can be performed.

7. Conclusions

In this paper, first I reviewed abduction and chance discovery. They are basic techniques for applications discussed in this paper. Key techniques and concept in this paper are chance discovery, affordance and chance discovery based curation. In chance discovery we try to discover a novel or rare event/situation that can be conceived as either an opportunity or a risk in the future. The concept of affordance was ecologically introduced by Gibson for perceptional phenomena. It emphasizes the environmental information available in extended spatial and temporal pattern in optic arrays, for guiding the behaviors of animals, and for specifying ecological events. Currently we focus on the part of communication between human and environment. Based on the concept of affordance, I proposed a dementia person support mechanism in which functions of things can be implicitly suggested to dementia persons. It is based on abduction framework and performed under the context of chance discovery to determine affordance.

For the affordance determination, I adopt a concept of chance discovery based curation. Where chance display strategies are discussed. By a proper curation, it becomes even for dementia persons to determine better affordance.

Actually, I show a dementia care system but discussions in this paper can be applied to several applications such as a decision making support system.

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