Enabling Rewarding Interaction with Anticipatory Behavior in Designed Environments

Paul Thorstein Nylund
Department of Design
Norwegian University of Science and Technology

ABSTRACT

The discussion surrounding adaptability of user-experiences remains frozen on the time domain, focusing on present contexts rather than preparing for continuous changes in future outcomes. Anticipation in smart products could reframe the discussion to that of constant future-context prediction, in turn leading to the formation of more valuable engagements with users via machine learning. The findings are based on a cross-analysis of survey responses as well as several papers spanning anticipatory design, machine learning, calm technology, and more. It is important to consider how anticipatory behavior on the part of computers should interact with human actors, especially regarding empathetic conclusions. The aforementioned topics are charged by the rising ubiquity of technology and its serving as more practical components of our daily lives.

KEYWORDS: interaction design, HCI, distributed cognition, anticipatory design, machine learning, calm technology, actualization, evolutionary design, mutuality

1. INTRODUCTION

What questions might be generated as a result of flipping the expectation of humans to anticipate functionality from the objects they use to the objects themselves possessing the ability to anticipate human interactions? The benefit of applying anticipatory behavior in designed environments can extend to a reduction of decision fatigue, redistribution of user activities, and less conscious interference on part of technological solutions. While there is a significant amount of published literature on anticipatory behavior as it applies directly to humans, anticipatory behavior as exhibited by the environments which we inhabit has received relatively little attention. Anticipatory environments could enable more meaningful interactions with people in terms of extending the limits of distributed cognition.

While anticipation is a potentially useful tool in daily interactions with the technology around us, consideration of the topic as relevant to increasingly ubiquitous computing remains beyond the limits of the public imagination. In order to better communicate the potential effects of anticipatory behavior on human actors, I introduce the following integral terms: designed environments and actualization.

1.1 Designed Environments

The designed environment describes any space -real or virtual- that has been considered in the service of a task. Through calm or active interactions, the human actor becomes a user in a such designed environment. These interactions are reciprocal by nature, as an environment may push and pull on the user through various means.

As a result of this user-environment relationship, a designed environment can be dynamic. For example, if a user chooses to hang their coat on a doorknob, he or she has augmented the function of that space to something other than its original intended function. Through the implementation of intelligent systems in designed environments, spaces can anticipate and respond to future user behavior, augmenting themselves to suit the needs of users within.

1.2 Actualization

Ekman [2] formulates a fine example of actualization as the manifestation of a digital image through different display mediums. As an allotment of ones an zeroes, a digital image only possesses the *"potential"* for being represented. As such, this potential can be realized through the manifestation of the image.
Similarly, Wamberg [10] wrote about the mind's tendency to "assemble" images internally before "transferring them to material representation". A just comparison can be made to the way computers might re-process information in deciding about how to represent it. The concept of *manifestation* can be understood as the transitioning from data to information in a process of considerate optimization [for humans]. While ones and zeroes mean very little to the casual observer, in processing raw data, they are interpreted and thus assigned a certain quality [2]. Likewise, Ekman compares different display mediums to materials; optimizations must be made in order to improve respective compatibility. Considering display mediums as materials that interpret and augment data allows us to investigate design elements as representations of the digital fabric that envelopes so many aspects of our lives. Actualizing data into information can be analogized to the nature of wave-particle duality in quantum physics, in that individual units are the result of intersecting fluidity. Much like waves, data envelopes the world around us, binding people and things. And similarly to the occurrence of particles, where data intersects, information can be born.

We can leverage actualization to make sense of the impact of designed environments on the human actors that inhabit them. By understanding how best to actualize certain functionality with respect to actors' state of being, we can design more empathetic environments that consider a wealth of data about present and future contexts. As machine learning gains momentum in practical settings, we gain access to improved methods of prediction. For various reasons, prediction-over-time could supplement increasingly affective environments, as computing becomes increasingly capable in the future. Throughout this paper, I explore how one could give design solutions that provide rewarding interaction with anticipatory behavior with respect to how it is received by human actors.

2. METHOD

The process of gathering information for this project involved an exploration about what anticipation meant in the context of human users and the concept of anticipatory design. Furthermore, machine learning surfaces as a particularly important factor in realizing anticipatory behavior in designed environments, in that it supports the process of anticipation as an alternative to traditional prediction models. Calm technology emerges as a means to actualize the behavior of integrated machine learning solutions as well as a viable approach to human-centered problems.

2.1 Sorting and Coding

Quotes were selected from the sourced documents and abbreviated onto sticky notes, which were grouped by similarity and coded;

factoids were arranged into clusters and assigned overarching themes. This led to a clearer overview of what subtopics could contribute to filling in and/or relating anticipatory design, including machine learning, and calm technology. Some earlier insights were made in how automatic reconfiguration [7] of actualizing-media in response to contexts involving human actors could relate to the selection of task engagement by designed environments. It became increasingly clear that the intensity of such actualizations would be judged by human actors' growing fatigue pertaining to decision-making throughout the day -a topic which invoked several ethical questions [5] about how and when anticipatory behavior could be actualized. Calm technology as an empathetic solution could serve to address such ethical concerns.

2.2 Survey

In addition to combing through a number of papers, I also leveraged the results of an online survey about flourishing, which was shared with twenty-four anonymous volunteers as part of an unrelated project at the University of Southern Denmark. In this survey, participants were asked to rank how a multitude of factors affected their ability to flourish as well as note any difficulties they may have faced in completing the task. The results were compared with findings from the more general research in order to better understand any wants or needs human actors might project into designed environments if engaged by its behavior.

3. RESULTS

Anticipation is more dynamic than prediction in that the behavior responds dynamically to changing inputs, generating more possible outcomes as new data is provided. Traditional computational methods mimic the calculation of specific outcomes in response to certain static data inputs, aligning this process more closely with prediction which is a quantifiable and definitive term [3].

3.2 Calm Technology

Calm technology can act as a patent extension of self; It is a seamless construction of distributed cognition, given that an object can become “invisible when it is most genuinely appropriated” [8]. Essentially, if an object is integrated well enough into one’s contextual perception, the user may distribute their attention to targets of their now extended ability. In this respect, a mug, for example, can recede to one’s periphery, allowing the user’s full attention to be dedicated towards their perception of the contents of the mug.

Calm technology revolves around users’ relationship to technologies exist in their periphery, or lying outside of one’s active focus. One such example is a window, in that it offers the passing of light from one room to another, yet its subjects do not constantly engage with it. When discussing the role of anticipatory behavior in designed environments, it is important to consider calm technology, because it allows us to consider such behavior as transitioning between users’ periphery and active engagement. It is in this transition that anticipation or prediction becomes manifested as action, rendering itself through a respective medium.

Offenhuber [4] asserts the contextuality of calm technology, as it "inherently" enters the actors' space given special circumstances. As anticipation attempts to act in response to future contexts, the behavioral enactment of anticipation in itself could be considered to be possessing a calmness. The concept of locatedness describes the contribution of peripheral elements to a person’s sense of context [11]. This is what allows actors to process their whereabouts through the observational presence of representational queues.

3.2.1 Machine Learning and Fuzzy Logic

Traditional call-and-response models fail to serve the ever-changing, constantly evolving reasoning on the part of human actors in response to their environments. Supervised learning, with respect to machine learning, enables users to continuously train the systems that they interact with. Machine learning algorithms can adapt as they receive new data, while we infer the consequences of their output. This relative degree of flexibility makes machine learning an ideal back-end platform for exhibiting anticipatory behavior in that it gives artificial intelligence its ability to process complex data structures. The ability of programs to constantly adapt to new data inputs had been dubbed by Choi as teleo-reactivity [1]. The resulting web of predictions is described by the system's range [3]. Processing complex data earns an important role in achieving the prediction of values in a fashion that parallels the ebb and flow of anticipation that human beings so often exhibit.

3.2.1 Time and Proactivity

While an intelligent system is able to gather contextual data to build an *understanding* of the world around it, in order to act in anticipation, it must do so before a possible future event takes place [13]. Because anticipation is constantly changing in response to changing contexts, an anticipatory system would have to constantly form new future outcomes.

The progression of time is an important component in designing environments that tend to the expectation of their inhabitants.

3.3 Issues

Anticipatory behavior is not without potential issues due to irresponsible implementation. While sharing an environment with an artificial actor that anticipates one's future behavior might sound like an Orwellian dystopia to some, understanding the psychological response of human actors in such environments could lead us to design more empathetic solutions.

3.3.1 Decision-making

Implementing anticipatory behavior in design environments may offer to alleviate some decision-making processes on the part of the user that are often subject to routine. Filtering away the burden of less important decisions can assist in reallocating related mental processes to tasks of greater personal importance. A subjectively positive improvement of personally important decision-making can result in increased flourishing.

The aforementioned survey [2.2] suggests a correlation between decision-making and flourishing. One participant specifically mentioned the concept of agency, or being able to make decisions according to their own will. Other participants expressed concern about how, success itself could hinder their ability to flourish if not met in some regard.

Another study led by Kathleen Vohs of the University of Minnesota suggests that engaging in self-control depletes the most energy regarding decision-making [9]. This is at odds with the effect of agency on flourishing. Just how much control would a user need to possess over their environment in order to realize personal improvement?

3.3.2 Control and Agency

Pieters [6] discusses variable perceptions of security with observation and degrees of explanation. The amount of agency possessed by a user in a certain context is integral in ensuring a sense of control, or security. Control, or security, can be addressed by anticipatory systems through "organization-based" [6] explanations. Pieters also touches on the role of organized explanations in supporting users' trust and/or confidence in a system. [6] In short, a user's feeling of security amidst an interaction with an intelligent system can be affected by the amount of detail in an explanation for an action. Providing either too little or too much information in an explanation may cause users to lose trust and/or confidence in a system's behavior.

3.3.3 Planning

Suchman [8] describes users' plans as driving factors in committing to action; User intention is a so-called "plan-for-action". Plans drive contextual goals, or desired end-states in different environments. Because actions alone cannot guarantee the course of a situation, it can be beneficial for anticipatory environments to learn to recognize users' plans in order to determine their own course of action. As such, understanding how a user may "filter courses" in response to live contexts can help a computer determine a more accurate future context projection.

3. ANALYSIS

In this section, I will address the balance of agency in multidirectional interactions, ethical concerns with respect to user trust and confidence, and give a brief overview of a project I have worked on which intends to illustrate the main themes of this paper through the construction of an installation.

A lot of research in anticipatory design discusses anticipatory behavior as it pertains to users themselves. Given the term 'interaction' implies mutual influence of one or more environmental actors, the value of a designed behavior can be measured by its subjective quality of reciprocity, or 'reward'. The subjective quality of such reciprocations is determined by human actors and the qualitative benefits the former possess.

While contextual systems are intended for current situations, anticipatory systems could predict future context states and enact functionality before a state is reached.

User intention should be measured in some respect to generate affect. Affect can be derived from the actualization of data pertaining to human activity as a way to better understand the reasoning behind certain behavior. A better understanding of user patterns could assist in anticipating user intention more effectively. Additionally, an anticipatory environment should aim to anticipate the consequences of the aforementioned intention.

3.1 Ethical Concerns

There are ethical dilemmas concerning agency and control, especially. Information should be communicated in a way that gives users enough leeway to make "unbiased" [6] decisions, thereby preserving the agency a user possesses prior to their entering an environment. This requires a level of justification for decisions made by intelligent systems. In this case, a justification can be given through the explanation of a system's behavior.

An explanation can still be effective even while the amount of informative detail is low; An intelligent system can instill confidence in human actors through explaining why it chooses to make a certain decision. On the contrary, providing more information can instill a greater sense of "transparency" and user trust.

There is the cost of convenience; Can convenience, in fact, be desired to the detriment of one's personal agency? Does improving the convenience of a set of functions, to an extent, limit one's agency to a degree more than is actually desired?

Another important consideration is the testing of users –something I exhibit in my project (3.3). Given the nature of machine learning, new data is needed to improve decisions. However, it is understandably difficult to collect new data if a user is not engaged. The solution might be to make certain considerations in the design of products to accommodate for unknown

Figure 1 - The installation in action

behaviors. We should consider how to separate ourselves from the consistent nudging by today's popular smart products and look for new ways of responsibly collecting and using data.

3.2 Experience Frameworks

Experiences are not finite, but an amalgamation of past memories and references that distort users' comprehension of reality. Designing frameworks for experiences rather than user experiences themselves helps us to circumnavigate cognitive distortions that draw users out of the activity they have engaged in.

3.3 Anticipatory Behavior in Action

To illustrate the effects of the interactions between anticipatory environments and human actors, an illustrative anticipatory environment was constructed to represent the effects of residual solutions -as pictured in Figure 1. The illustration consists of a "lamp" suspended by three strings in a fashion that mimics a delta robot. The lamp is then repositioned via stepper motors to enter the personal space of a human actor performing a certain activity. The actor can either choose to accept the lamp's company or push it away. Regarding the latter, the lamp then returns to its initial resting position in the actor's periphery. While the lamp may periodically return to the actor a number of times, it eventually learns to avoid doing so while the actor performs the aforementioned activity.

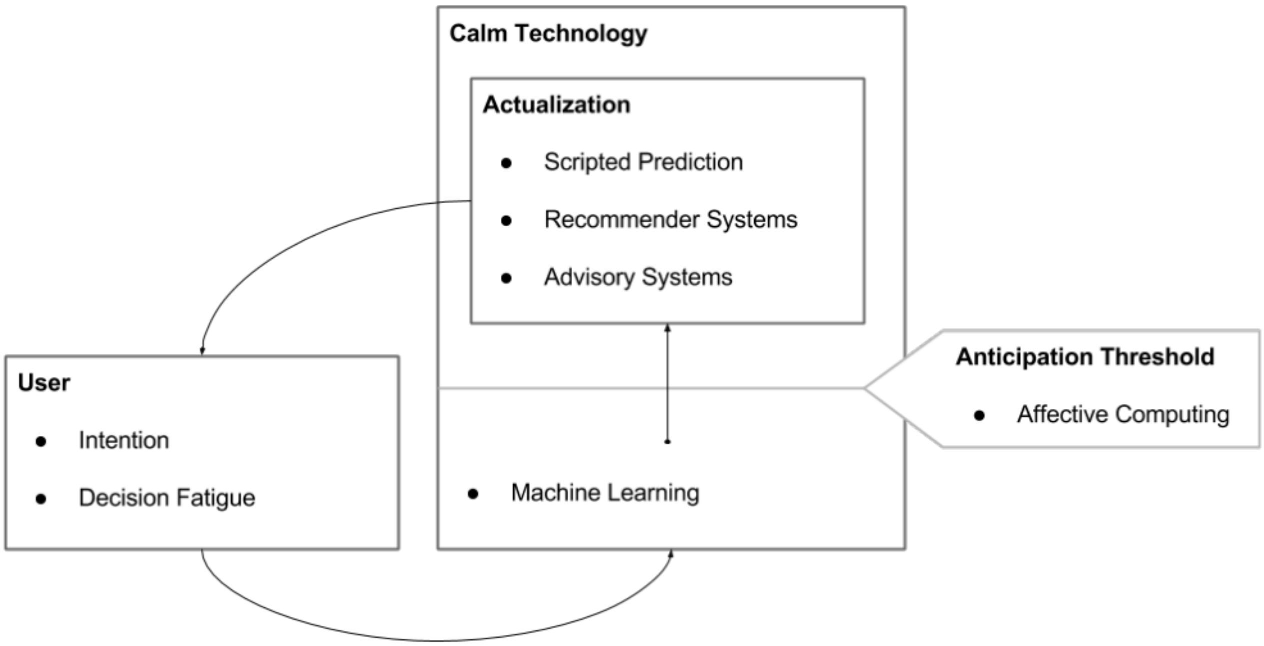

Figure 2 - The anticipatory environment

This type of evolving anticipatory behavior could also be applied to digital user interface elements in any dimension. By augmenting interfaces elements over time in response to users' continuous behavior, software developers and user interface designers could be freed from focusing on trivial tasks such as making minor aesthetic adjustments to buttons, forms, and the like. Evolving elements could improve the click-through rate throughout various interfaces by anticipating the behavior of unique users. This would in turn allow the same developers and designers to focus their efforts on addressing more abstract hurdles such as finding better ways to usher in more humanity and subsequent emotional connection to their services.

4 DISCUSSION

Figure 2 describes the collaborative interaction between an anticipatory environment, designed with respect to calm technology and the utilization of machine learning processes. A machine learning algorithm responds to training data generated by the user and their environment. When the output of the algorithm matches a predetermined set of requirements, or the anticipation threshold, features previously hidden or delegated to the user's periphery are actualized into the user's scope of attention. This actualization can be manifested in the form of scripted prediction, recommender systems, advisory systems, or direct action. The way a user responds to this stimulus can be recycled to affect the behavior of the anticipatory environment.

As machine learning models become better at predicting outcomes, taking into account "fuzzy" data, our intention alone may be enough to have tasks completed before we are able to actively engage in them.

If a peripheral state is meant to blend in with an environmental context, an active state should purposefully attract a user's attention. This can be achieved through multitudes of techniques, one of which is improving a user's sense of locatedness. One can alleviate the amount of cognitive load experienced through decision fatigue as it may pertain to making sense of unfamiliar environments. Hence, in designing solutions that intend to minimize decision fatigue, it is important to consider how these solutions 'blend' into a user's peripheral sensory scope.

The anticipation threshold describes a point in time when an anticipatory environment decides to actualize features that were previously either limited to a user's periphery or hidden entirely. This threshold is closely related to user affective computing, in that an anticipatory system would have to understand in some capacity when it should actively engage in a user's environment.

It might be useful to consider solutions as integrations, complementing experiences through anticipatory behavior as sensory augmentation. While popular physical and digital products alike are, to an extent, self-contained and quantifiable, integrated solutions may be derived from the environment itself. Existing environments can thus be subservient to the changes brought on by such integrations. An integration is subject to change following its implementation in an environment.

They can be contextual, reacting to depth and light. Implementing anticipatory behavior could enable solutions to become part of the environment, blending in and evolving along with it. Ensuring that the user feels either trust or confidence in a system is vastly important in allowing users to determine situation outcomes. [6] Anticipatory systems need to be constantly formulating future contexts based on current user activity, so it is necessary that these human actors are given the agency to make decisions in response to their sense of locatedness until those future contexts take place. This can aid in diverting the center of attention away from a system's actionable components unless summoned, allowing anticipatory systems to become one with a human actor's periphery, allowing the latter to carry out actions typically associated with analogous environments.

4 CONCLUSION

4.1 Findings

Given that anticipatory behavior is inextricably linked to major growth items such as calm technology, ubiquitous computing, and machine learning, its consequences, whether it is implemented, may be hard to avoid in the foreseeable future.

4.2 Limitations of anticipatory design

There is the danger that anticipatory behavior relies too heavily on advanced prediction models, thereby requesting large amounts of data that could be exploited by corporations. It is vitally important that we design products that engage responsibly, considering user agency in an empathetic manner.

4.3 What's next?

An increasingly ubiquitous amount of personal connected devices build in-depth qualitative data profiles of who we are, constantly improving contextual predictions about what we would like to see in present contexts. Seeing as smartphones in 2017 are packing a large number of advanced sensors, the resulting data is diverse, and the information the latter might lead to could pave the way for anticipation at scale. Smartphones in 2017 are beacons of predictive environments, serving as a limited lens through which users engage with the environment they are existing within. Improving the dynamism of present contextual predictions through the implementation of constant future-context anticipation could lead to a more empathetic mutuality between humans and machines.

4.4 Recommendations for future research

Evolutionary design could be an interesting avenue through which to build on the findings in this paper (ex. How to scale repeatable design practices). Can one use the themes in this paper as tools to analyze environments surrounding users? Specifically, do designed environments have boundaries, and who makes them? How can we use these terms to reverse the polarization of hardware and software in order to design richer, more holistic experiences.?

REFERENCES

[1] Choi, D., & Langley, P. (2017). Evolution of the Icarus Cognitive Architecture. Cognitive Systems Research.

[2] Ekman, U. (Ed.). (2013). Throughout: art and culture emerging with ubiquitous computing. MIT Press, 96.

[3] Howard, A. (2007). Anticipatory Design (Doctoral dissertation, North Carolina State University).

[4] Offenhuber, D. (2013). 24 Kuleshov's Display—on Contextual Invisibility. Throughout: Art and Culture Emerging with Ubiquitous Computing, 431.

[5] Picard, R. W., & Picard, R. (1997). Affective computing (Vol. 252). Cambridge: MIT press.

[6] Pieters, W. (2011). Explanation and trust: what to tell the user in security and AI?. Ethics and information technology, 13(1), 53-64.

[7] Schilit, B., Adams, N., & Want, R. (1994, December). Context-aware computing applications. In Mobile Computing Systems and Applications, 1994. WMCSA 1994. First Workshop on (pp. 85-90). IEEE.

[8] Suchman, L. A. (1987). Plans and situated actions: The problem of human-machine communication. Cambridge university press.

[9] Tierney, J. (2011). Do you suffer from decision fatigue. New York Times Magazine, 33.

[10] Wamberg, J. (2013). 27 Toward a (Re) Constructed Endosemiotics?: Art, Magic, and Augmented Reality. Throughout: Art and Culture Emerging with Ubiquitous Computing, 465.

[11] Weiser, M., & Brown, J. S. (1996). Designing calm technology. PowerGrid Journal, 1(1), 75-85.

[12] Williamson, J., Murray-Smith, R., Blankertz, B., Krauledat, M., & Müller, K. R. (2009). Designing for uncertain, asymmetric control: Interaction design for brain–computer interfaces. International Journal of Human-Computer Studies, 67(10), 827-841.

[13] Zamenopoulos, T., & Alexiou, K. (2007). Towards an anticipatory view of design. Design Studies, 28(4), 411-436.