Goldilocks

Just Right Ubiquitous Computing Experiences in Motion

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Abstract

With the rise of situationally aware technologies and wearables devices, ubiquitous computing empowers a new generation of personal and environmental interfacing, making this the age of *hyper* personal mobility. This thesis explores how we might navigate through a society pervasive with stimuli and digital technology. *Goldilocks* builds upon the long discussed human computer interaction research of Mark Weiser, and dives into a new frontier of invisible computers based upon qualitative research and human centered design. Through generative interviews, design thinking, and exploratory prototyping, *Goldilocks* provides a critical Ubicomp Design Framework to guide creatives as they develop seamless, *just right* experiences. Led by eight guiding principles —*just right*, *calm*, *intuitive*, *honest*, *enabling*, *contextual*, *accessible*, and *thoughtful* technology— this thesis emphasizes that we can be more considerate and deliberate with technology.

Keywords: ubicomp, inclusive, framework, augmented reality, information, human interface

Ubicomp Design Principles

● **Just Enough**

Products and experiences should aim to provide exactly what is valued by an user in any given context or situation.

● **Calm**

The UX should never be intrusive such that it distracts the user's attention or disrupts the user's primary task.

● **Intuitive**

Build a relationship of trust with people, based upon reliability, familiarity, transparency, and intuitiveness.

● **Honest**

Enable interactions and the passing of information without relying upon negative, addictive design features.

● **Enabling**

Minimize the number of tedious and undesirable tasks that must be performed by people without taking away control.

● **Contextual**

Shrink and expand parameters to meet the fluctuating needs of users.

● **Accessible**

Should not be obtrusive without purpose, and should function regardless of a user's constraints.

● **Thoughtful**

Be cognizant of the negative social effects that thrive from information bubbles and echo chambers.
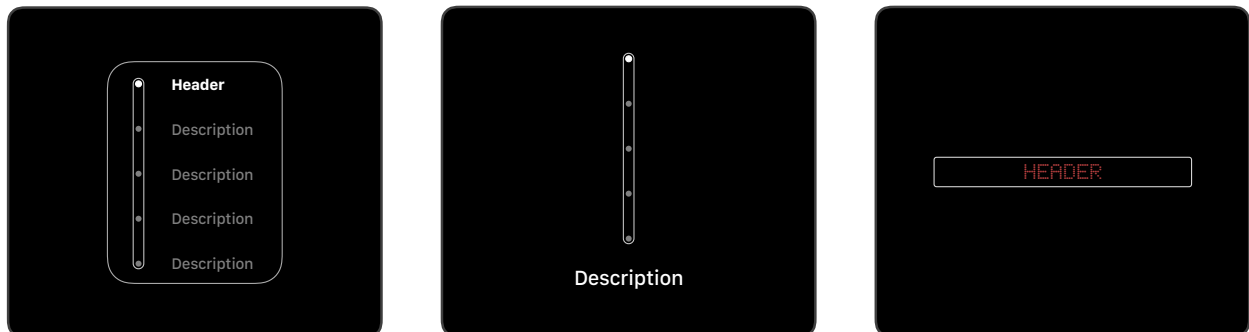
Ubicomp Design Principles

● Just Enough

Products and experiences should aim to provide exactly
what is valued by a user in any given context or situation.

Definition — At the foundation of ubicomp design is the cardinal philosophy that *"just right is just enough."* Ubicomp products and experiences should aim to provide exactly what is valued by a user in any given context or situation, but it should never enlist so much of this information that it overwhelms or overloads the cognitive mind. Cognitive overload harms the end user and does not fulfill the fundamental goal of a product, which is to assist and empower people.

Intensity — Users desire varying levels of information interaction depending upon a number of factors such as the situation, objective, fidelity, topic-matter, opportunity cost, and more. Ideally a ubicomp system would fuse extrinsic *(environmental awareness)* and intrinsic *(user awareness)* sensor data with machine learning to precisely detect a user's needs, then return with just enough of a response to fulfill the user's objective. Too much content can be cognitively obtrusive whereas too little can be confusing or frustrating.

Approach — Sensor and information fusion is often too computationally intensive. Instead, designers can simplify the technical complexity by focusing upon the core objectives of the user and tackling small moments of complex situations. By using focused interactions, ubicomp can assist users with just enough of a response without overcompensating or overpromising. Specifying precise use case interactions make the objective definable and enable the potential for future sensors or software to expand the experience further.
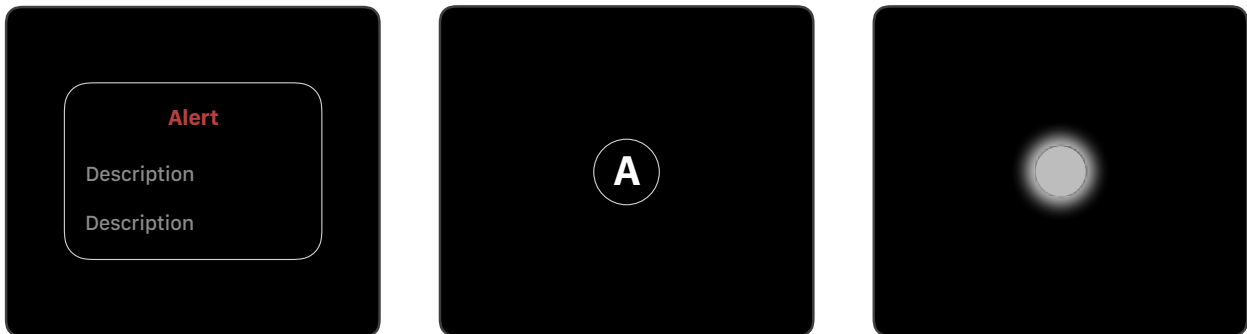
Ubicomp Design Principles

● Calm

The user experience should never be intrusive such that it
distracts the user's attention or disrupts the user's primary task.

Definition — Ubicomp experiences should feel seamless and invisible. They need not be physically invisible nor purposely concealed, but the user experience should never be intrusive such that it distracts the user's attention or disrupts the user's primary task. Nudges or calm cues such as natural expressions and nurtured gestures can be used to provide just enough of an impulse for interfaces to communicate the necessary information across elegantly.

Intensity — It is at times necessary for a system to obtain a user's attention to perform a desired task or to provide a high priority alert. Obtaining a user's attention is dissimilar from intrusiveness. For example, in a high priority scenario when the opportunity cost for ignoring the alert is too great, a user's attention is necessary to meet a desired objective. On the contrary, when an interaction is intrusive, it draws the user's attention away from their momentary tasks, which may be both counterproductive and disruptive.

Approach — For ubicomp design, attention based interactions should ideally be used sparingly unless it is absolutely necessary to accomplish a task. In most cases, interactions can be glanceable while still relaying the desired information to the user. By familiarizing users to alerts and nudges through conditioning or historical experiences, ubicomp interfaces can be lightweight and informative without shifting a user's focus from their momentary objectives, making the interaction easily dismissable if so desired.
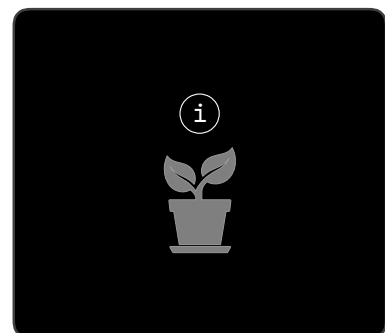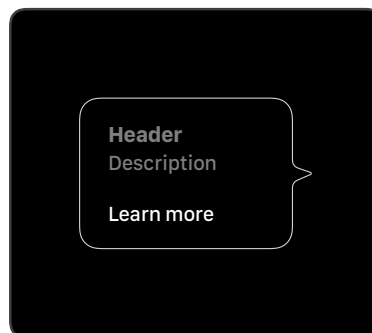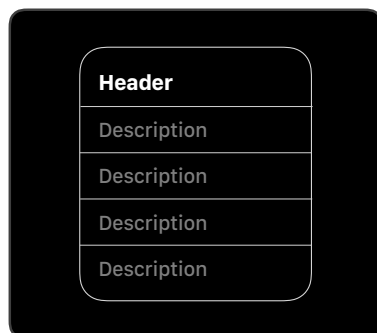
Ubicomp Design Principles

● **Intuitive**

Build a relationship of trust with people, based upon reliability, familiarity, transparency, and intuitiveness. This critical relationship affords greater adoption, manages expectations, and provides opportunities for products to evolve with their users.

Definition — Information tools must be carefully crafted as they are sources of knowledge. They should build a relationship of trust with its users, based upon reliability, familiarity, transparency, and intuitiveness. This critical relationship affords greater adoption, manages expectations, and provides opportunities for products to evolve with its users.

Intensity — Ideally, information should always be simple and precise. However, just as people speak in a number of languages or dialects, information content and computer processes can also be interpreted in a variety of ways. Therefore, it is critical for ubicomp design to be conscious of the varying degrees of user interpretation when it comes to human-machine interfaces and data. The method to which content is presented can directly impact whether users will be attentive or perceptive of the information being delivered.

Approach — To build a relationship of trust, ubicomp design should present complex information in a versatile and easily consumable manner. This content should have hierarchy and acumen, making it easy for users to choose freely whether they desire more or less information. Such experiences should be transparent and intuitive, meaning that users should dependably be able to access or engage with the information at any time without going through unnecessary steps or being oblivious to additional content/features.
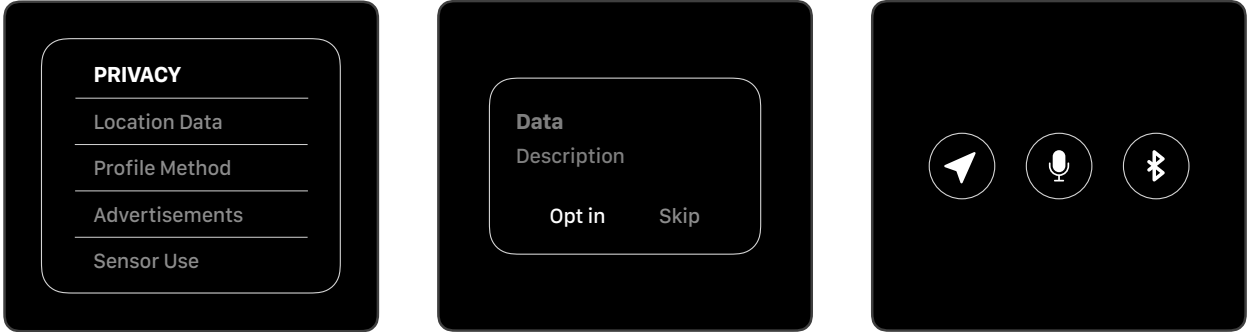
Ubicomp Design Principles

● ## Honest

Enable interactions and the passing of information
without relying upon negative, addictive design features.

Definition — Ubicomp products and experiences should enable interactions and the passing of information without relying upon negative, addictive design features. In a time when attention economics and surveillance capitalism has become the norm, information tools must take into consideration the development of healthier habits that generate a sense of contentment. Digital wellbeing and privacy are intrinsic rights for every individual.

Intensity — Digital experiences should always be direct about their intended purpose and thoughtful about their design. Features should provide a clear and direct value to its users while being conscious of an user's digital health. Under no circumstance should personal data be used in hidden or indirect manners, and data use must require the explicit consent of the user. Users should be unambiguously aware of each objective to which they are consenting to. Experiences should aim to help users be mentally and digitally healthy.

Approach — Data usage should always be direct. Every feature should educate the user on its purpose and ask for opt-in consent. Ubicomp designers should be aware of the ways in which users interact with digital content. Through thoughtful design, products can align user objectives with healthier digital habits, nurturing a less addictive user experience. For example, infinite timelines are well known to have addictive attributes, so interfaces can be designed to quell a user's desire to continuously scroll.

PRIVACY		
Location Data		
Profile Method		
Advertisements		
Sensor Use		

Data
Description

Opt in   Skip
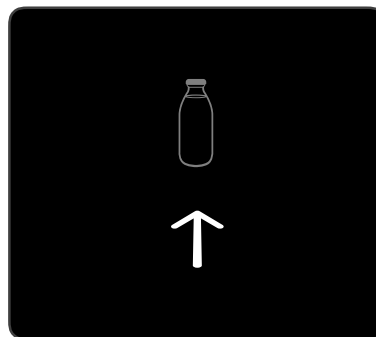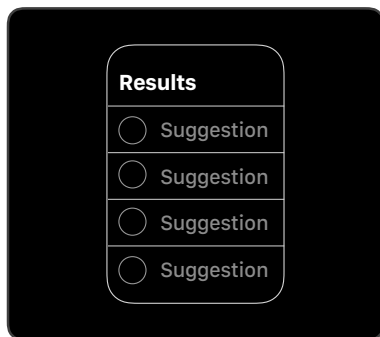
Ubicomp Design Principles

● **Enabling**

Minimize the number of tedious and undesirable tasks that must be performed by people, but it should never take away an individual's sense of control.

Definition — Ubicomp experiences should minimize the number of tedious and undesirable tasks that must be performed by people, but they should never take away an individual's sense of control. Intelligent systems should never be black box automations, which can lead to dismissive or misinformed perceptions of technology. Ubicomp should seamlessly assist the user while providing the versatility to offer control when so desired.

Intensity — Experiences should empower users by learning from their needs and preferences. Just as people will learn from one another's habits, ubicomp experiences should adapt and meet the particular needs of each individual. Certain tasks are random or indeterminable, while other tasks can be simplified or predicted based upon intrinsic and extrinsic context. A forgiving user interface will help to reduce user dissatisfaction when the inevitable deficiency occurs.

Ideally — A ubicomp system should reduce the number of tasks or variables that a user needs to consider in a given situation. Modern intelligent interfaces such as voice assistants or automation often make it difficult or impossible for users to efficiently refine their computer input when an interaction fails. Ideally, the system will provide a seamless and easy means of control, even for dynamic or natural UI tasks. Ubicomp should make tasks simpler, but it should not substitute the user or reduce a user's sense of control from the experience.
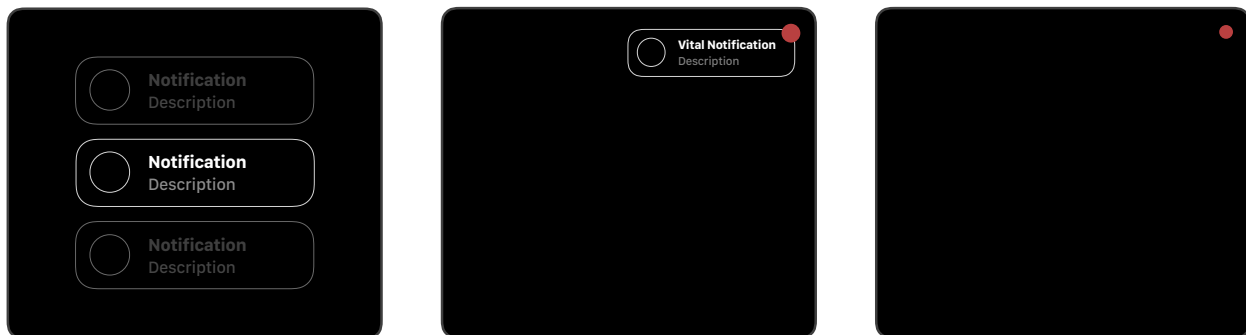
Ubicomp Design Principles

● **Contextual**

Shrink and expand parameters to meet the fluctuating needs of users.

Definition — Ubicomp experiences should shrink and expand its parameters to meet the fluctuating needs of users. Building trust with users, situational adaptivity enables an anthropomorphic sense of awareness and intelligence. These experiences must be transparent and sensible with data utilization, and must never intrude upon the fundamental human right for privacy.

Intensity — Computer systems provide a myriad of features that assist the diverse needs and backgrounds of its users. Present interfaces condense and extrapolate its functions to meet the generalized needs of users. As products continue to add new abilities to its growing feature set, the lack of personalization can make oversaturated experiences abrasive, impersonal, and overwhelming. Instead, such a system should adapt situational and historic data to parameterize the momentary objective of its user.

Approach — An ideal contextual interface should consider the many variables of a situation including but not limited to the location, position, time, event, emotional, historic, and user(s) context. Given the complexity of such an experience, numerous data points would be required. Given the large range of scenarios and use cases, a ubicomp interaction can adapt its interface over time to learn from and build a relationship with its user. This can help to build user trust and reduces the potential for generating unrealistic user expectations.
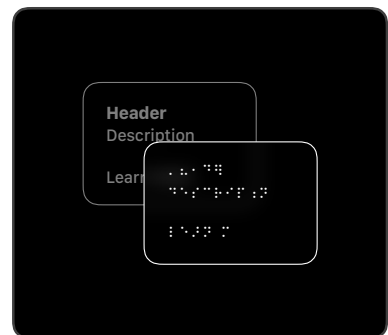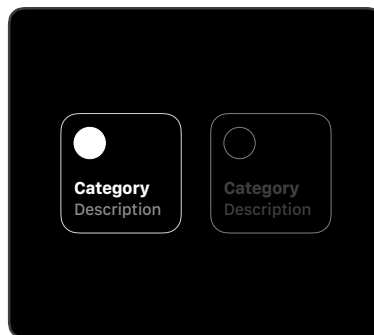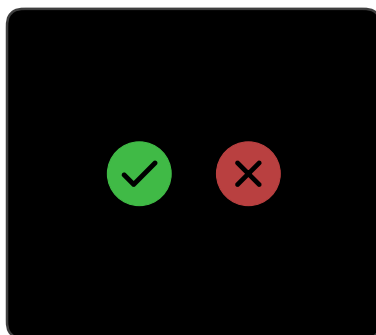
Ubicomp Design Principles

● **Accessible**

Should not be obtrusive without purpose, and should function regardless of a user's physical and cognitive constraints.

Definition — Ubicomp interfaces should seek to be universally approachable and accessible. They should offer clear affordances by communicating with a sense of hierarchy and, if necessary, a sense of urgency. Such experiences should not be obtrusive without purpose, and it should function regardless of a user's physical and cognitive constraints.

Intensity — Consumer experiences should be created with universal design and ease of use in mind. Regardless of a user's physical or mental abilities, the product experience should be accessible and adaptable for each individual's needs. Universal design goes beyond making an interaction possible, but aims to create an inclusive experience for all users. In ubicomp design, accessibility prioritizes the reduction of obtrusive or cognition heavy tasks such as alerts and complex UIs to make individual tasks simpler and more lightweight.

Approach — Interfaces and interactions should be built from the ground up to be adaptable for different accessibility needs. In addition, content must not be presented in a worsened user experience when an accessible function is being utilized. Ubicomp designers should consider the end to end user journey for all cases in order to ensure a seamless and fluid experience from beginning to end. Particularly, digital content should optimize for information hierarchy and urgency to help reduce cognitive switching and mental stress.

Ubicomp Design Principles

● Thoughtful

Be cognizant of the negative social effects that thrive
from information bubbles and echo chambers.

Definition — Ubicomp experiences must be cognizant of the negative social effects that thrive from information bubbles and echo chambers. The design of information services must strive to minimize hive-minded thinking and to encourage civil discourse. Plurality of thought should be a core component of "just right."

Intensity — The goal of thoughtful design is to help users be aware of the potential negative effects of echo chambers. By designing experiences that consider the impact of information bubbles, the goal is to spread diverse thinking and to provide users with a more comprehensive information database. Such a system helps to reduce implicit bias, partisanship, and external manipulation. Given the ease for intelligent systems to generate user profiles and echo chambers, it is important for designers to be considerate of the social challenge.

Approach — Ideally, a thoughtful system would balance the content presented transparently with an equal share of diverse topics and varying perspectives. Given the complex nature of such an experience, ubicomp designers may choose instead to educate users to be more aware of echo chambers. This can arise as intelligent systems that check the veracity of the information presented in a news source or as meaningful summaries of the user's digital interactions in order to highlight the potential bias of an individual's information content.
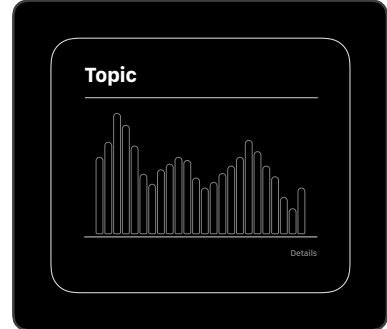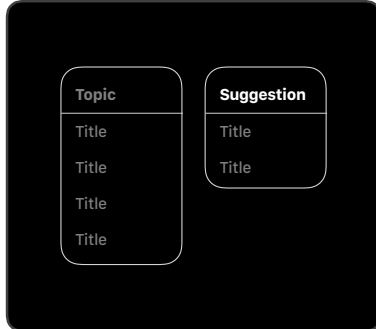
Mobility Events

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Snap

Moments measured in seconds or less. This is targeted at time sensitive experiences that may not be predictable by the user. Consider whether users are being overwhelmed by a surplus of external stimuli.

Example 1: Boarding the correct subway in the last fleeting moments before their departure

Example 2: Driving a car and making the decision to turn onto the correct street during a fast moving traffic scenario

Core principles: *just enough, calm, enabling, contextual, accessible*

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Intermittent

Moments when the user is curious but not able to easily manually pull a request. This is targeted at calm or peripheral based alerts. Consider whether the user is preoccupied and how to best engage their focus in a glanceable manner.

Example 1: Subway rider in need for transit progress *(ETA)* or stop information

Example 2: Finding friends in a dense or busy environment, and being aware of their general direction based on user position

Core principles: *just enough, enabling, contextual, accessible*

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Proximal

An user's momentary or contextual goals based upon their proximity, location, and position. This is targeted at the fluctuations in user needs based upon the tiered 1, 2, and 3 read. Consider whether the information presented should be spontaneous or rigid.

Example 1: Identifying desired shopping items in the grocery

Example 2: Searching for nearby restrooms along the desired walking path in public

Core principles: *just enough, calm, intuitive, honest, enabling, contextual, accessible*

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Habitual

Moments driven by a user's particular mental model for an environment. This is targeted at using a user's familiarity with their physical environment to assist augmented interactions in blending in and feeling intuitive or natural. Consider which user habits and/or environments are malleable, and find ways ways to improve the accessibility of interactions.

Example 1: Displaying personalized content on airport signs or billboards, removing extraneous content

Example 2: Showing user specific content, such as rideshare details or ETAs, on existing street billboards and signs

Core principles: *just enough, calm, enabling, contextual, accessible, thoughtful*

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Complementary

Moments when more information or expertise can be provided through an external companion device. This is targeted at situations when users are facing complex interactions that may be both unfamiliar or complex. Consider how the content can be more easily and non-intrusively visualized for users.

Example 1: Identifying how ripe produce are in a grocery

Example 2: Interpreting and making aware of a particular ingredient or material in an item based on a particular need

Example 3: Visually cleaning up complex or secondary interface functions *(i.e. phone app)*

Core principles: *just enough, enabling, intuitive, honest, contextual, accessible, thoughtful*

Devices

Augmented

Fun, artistic, or informative digital experiences that blend seamlessly into the real world.

Augmented content presents itself in a glanceable manner and relies upon intelligence to reduce or eliminate the need for user interactions within AR.

Mobility content should not use attention seeking or addictive visuals and interactions. Instead, these experiences should complement the real world and blend naturally or invisibly into the environment like a 6th sense, allowing the user to focus on their objective.

Screen

Information dense content that require extended user input within a short duration of time.

Experiences that require users to fully disengage from the real world should be developed for an optimized mobile device such as a phone or tablet. Content should dynamically transition between various platforms depending upon a user's desired input method.

Consider the intuitiveness of each interaction on a situational basis and limit the number of transitions to no more than two handovers per use case.

Lightweight

Quick interactions that can act both independent of or complementary to augmented and screen based devices.

Calmly identify extrinsic and intrinsic user contexts to supplement the intelligence in other devices. Sensory features like haptics nudge and subtle communicate with users.

Interactions with lightweight devices should be efficient and glanceable. While it is not necessary for a wearable to blend into the real world, such experiences should not be intrusive to users.

Assistant

Interact with content in an intuitive and direct manner, reducing cognitive effort.

Natural interfaces such as gesture, vision, or voice should make communication between users and artificially intelligent assistants quick and effortless.

Interactions should be contextual and peripheral, meaning that users should be free to focus on other tasks while communicating with the assistant. The device should adapt to the user's needs and adjust its parameters based upon the situation.

A precise or particular interface, feature, and objective. The experience is limited to the functions within a platform UI or a performed application action. Such interfaces require active user participation, and enables the system to have more control

Glanceable content is optimized for momentary experiences and lightweight interactions. Such content displays a variety of easily digestable information and tailors the content on a semi-contextual basis. The system is user defined and adjusts the

An extrinsically and intrinsically aware system that adapts its objectives to the situational needs of its user based upon historical and contextual information. The automatically adapting experience would prescribe just the right amount of content desired by the user

Architecture

Application

A precise or particular interface, feature, and objective. The experience is limited to the functions within a platform UI or a performed application action. Such interfaces require active user participation, and enables the system to have more control over the entire sensory UX.

Widget

Glanceable content is optimized for momentary experiences and lightweight interactions. Such content displays a variety of easily digestable information and tailors the content on a semi-contextual basis. The system is user defined and adjusts the amount of content provided.

Predictive

An extrinsically and intrinsically aware system that adapts its objectives to the situational needs of its user based upon historical and contextual information. The automatically adapting experience would prescribe just the right amount of content desired by the user without being intrusive.

Systems

Open Source

Enable open collaboration and a lower barrier of entry for users or developers to utilize the system. Increase the overall detection of bugs through a larger audience of developers and white-hat hackers.

Industry standardization provides a more consistent experience across the board for most applications. Allow for interoperability between various platforms to create a shared and potentially free experiences for users.

Proprietary

Have increased control over the entire user experience, tailored specifically for each platform. Enable simpler, more defined user experiences that are not pre-constrained by the limits of a generalized platform.

Ensure fluid and seamless integration between different platform features. Provide updates more often with a focus on the most desired user functions. The system requires little to no advertisements or user data to maintain function.

Hybrid

Build a custom experience via a proprietary approach while employing open source services within the tailored system. Use a gateway such as a browser to access open sourced experiences while controlling other key functions.

Joint open source software services that utilize a closed hardware platform are more commonly used today.

Technologies

High Precision Positioning

Nearness

Our proximity to the world around us can be measured on a centimeter or smaller scale. With technologies such as ultra wideband, our nearness to our surrounding will offer new degrees of intelligence for contextual awareness and ambient intelligence.

Experiences will identify what is around us faster than the eye, simplifying our environment down to only what is needed and removing visual pollution.

Discovery

Miniaturization and low energy devices have made way for integrated everyday devices and the IoT. With scaled manufacturing and the rise of high precision positioning, it is not inconceivable to imagine a world that is fully connected.

Connected objects could be identifiable through mapping or augmented user interfaces, making even the most complex or dense environments easily discoverable.

Touch

Infrared sensors provide a new dimension for augmented touch input. When body heat is transferred from a user's contact *(i.e. hand or fingers)* with a physical surface, this can indicate an user's input.

In combination, augmented reality and infrared mapping turn any surface in the real world into a dynamic digital interface. This enables new input mechanisms for theoretically any surface.

High Definition Maps

Cities

Urban areas will be mapped in detail and updated regularly. The map renders will enable augmented experiences to quickly and efficiently place spatial content on-device. HD maps will enable live interfacing between digital content and a user's instantaneous focus or proximal orientation.

Indoor

Interior mapping will provide a new degree of awareness for not only wayfinding but also object recognition. A HD interior map will provide augmented experiences with an acute awareness of the existing infrastructure including but not limited to the layout, media screens, and objects.

Vehicles

Given their enclosed and tailored interiors, vehicles offer an optimal environment for mobile augmented reality. LIDAR and predefined models generate detailed exterior and interior maps, enabling a versatile platform for dynamic and mobile augmented reality experiences.

Contextual Awareness

Location

A user's location can be used to provide an awareness of the places or general environment of a user's ambient context.

Precise awareness through a user's orientation or proximity to nearby objects and people will assist in providing a more refined view into an individual's present focus or attention.

During a fast paced or snap moment *(i.e. while driving or in transit)* predictive location awareness can help ubicomp experiences to efficiently and rapidly synthesize relevant user content using historic user preferences and high definition map data.

Situation

Users have unique personal boundaries and objectives for each particular scenario. It benefits the overall experience if products are able to account for fluctuating user needs by being aware of any changes to situational context.

People have different needs depending upon their mood, health, and comfort levels. Emotional awareness or intrinsic awareness can help ubicomp experiences be better attuned to a user's needs and adapt what or how content is presented. Like a friendship, situational awareness helps to build a greater degree of trust with users.

Eye

Fusing environmental imaging with eye tracking enables a new standard for precision attention tracking.

Not only does eye tracking provide details on a user's momentary focus, it also offers an approximate understanding for a user's intrinsic interest or awareness level for an object by measuring how long a person has gazed upon particular target.

The rate that a user's eye focus shifts offers additional data for ubicomp to consider when determining the cognitive load of an interface.

Intensity

Users have particular needs for each given moment. By understanding the user's objective for a given scenario, interactions can adjust the volume of content presented to best suit the context.

User objectives can be intelligently determined via patterns in previous user decisions, measured via a user's present environmental attention, or they can be approximated via machine learning and aggregated data from a large set of similar users or groups.

Intensity can be affected by other variables such as location or situational changes.

Prediction

By understanding a user's habitual behavior or by approximating the general behavior of similar user groups provides a sixth sense for ubicomp to better refine interactive experiences.

Intelligent prediction algorithms require large amounts of data to accurately determine patterns in user behavior. Systems that ask the user to assist with training will help to reduce learning time and more accurately generate specific contextual suggestions.

Behavior can also be deciphered through simple processes such as manual programming or natural language processing *(i.e. understanding speech in messaging or calendar apps)*.

Object

Detecting physical user interactions with objects in the real world will bring a new degree of realism to augmented experiences.

By bridging the gap between real and digital world interfaces, object detection will help to realistically place digital visuals onto the real world. Object detection will help to facilitate this by measuring precisely when users make contact with physical items, thus detecting real world inputs as precisely as touch inputs on a touchscreen interface.

Image recognition and touch detection identify when a tap or click in digital and augmented space is made, measuring precise user inputs in a non-intrusive manner.

Many of the technologies introduced above represent *extrinsic* or environmental awareness.

Such technologies enable products to perceive and adapt

User aware technologies are a growing category of devices that can perceive the cognitive or biological state of a user, making them *intrinsic*.

Heart rate or sleep monitoring

Intensity can be affected by other variables such as location or situational changes.

Behavior can also be deciphered through simple processes such as manual programming or natural language processing *(i.e. understanding speech in messaging or calendar apps)*.

Image recognition and touch detection identify when a tap or click in digital and augmented space is made, measuring precise user inputs in a non-intrusive manner.

Contextual Awareness Continued

Extrinsic

Many of the technologies introduced above represent *extrinsic* or environmental awareness.

Such technologies enable products to perceive and adapt to what is happening around a user. Location, weather, object recognition, calendar, ambient brightness, and loudness are all examples of extrinsic data.

Intrinsic

User aware technologies are a growing category of devices that can perceive the cognitive or biological state of a user, making them *intrinsic*.

Heart rate or sleep monitoring approximate a user's health and state of mind. With further refinement, intrinsic awareness will elevate product adaptivity and personalization.

Machine Learning

Recognition

Precise and efficient object ID via image recognition will be critical to augmented experiences. When systems can classify a wide range of objects on-device (reducing privacy concerns) and in parallel *(multiple objects at once)*, such products will become invaluable to users.

Trends

Detecting patterns in user or situational behavior will be crucial for devices to anticipate user needs and adapt to contextual objectives in a user friendly manner. As computers utilize greater degrees of predictive intelligence, trend analysis will close the gap for natural user interfaces.

Filter

Computers are incredibly powerful when it comes to analyzing and sorting through large amounts of data. Machine learning and indexing enable a new kind of data visualization by simplifying dense content and showcasing only what is needed by the user on a case by case basis.

Intelligence

Conversational machines will trigger rapid innovation in natural user interfaces. As input mechanisms become akin to human interaction, the divide between users and computers will become nearly nonexistent. Technology will pervade our lives, enabling a sixth sense for information intelligence.