Roomba+Clips Cam: Exploring Unpredictable Autonomy in Everyday Smart Systems

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Abstract

We present a novel prototype to explore themes of unpredictable autonomy in everyday smart products. We construct an interactive prototype that combines two autonomous everyday consumer products: an autonomous vacuum cleaner that cleans where it decides, and an autonomous camera that takes photos when it decides. Through this process we reflect upon the value and risks associated with everyday unpredictable autonomy, and the need to introduce guardrails and overrides. This demo will allow conference participants to interact with variations of the prototype in order to experience unpredictable autonomy with everyday smart systems.

Author Keywords

Internet of Things; privacy and security; speculative design; design

CSS Concepts

•Human-centered computing~Human computer interaction

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Initial Concept: A Nest Rides a Roomba into a Bar

these themes, we began by studying existing autonomous smart products. We then created a novel operational prototype by combining two autonomous consumer products: the iRobot Roomba robotic vacuum cleaner and Google's Clips hands-free smart camera. (The Google Clips was recently discontinued in Fall of 2019. [12]). The Roomba is a frequent object of study and exploration in HCI [e.g., 1,4,6,10]. Emerging smart cameras such as Google Clips appear to be less studied. This work is part of a broader project using design perspectives to understand and explore implications of IoT and sensing [8,9,10,11].

Design Trends: More than a Camera, a Security Device, or an Inanimate Tool

The project extrapolates three interrelated trends [9,11]. First, standalone smart cameras are technically much more than cameras. Today's smart security cameras automatically alert users when motion or people are detected, they allow homeowners to view live camera feeds from their phones, and some even identify individual faces. And as with many smart products, security cameras such as Nest Cam collect environmental data including device temperature and ambient light.

Second, smart security cameras offer more than security. The Nest Cam may be sold as a security camera, but its marketing materials often suggest it as a lifestyle or entertainment device with analogies to social media and handheld digital cameras. For example, Nest users are invited to share and submit their favorite videos captured with the smart security cameras. Selected videos are posted on the Nest Videos webpage under categories that, in addition to "Security", include "Mystery Solved", "Family Moments", "Pets", "Nature", and "Timelapses."

Third, smart security cameras are more than inanimate tools. They are smart, technically speaking, meaning they are both network connected and AI-powered. This allows them to operate with degrees of autonomy and "intelligence", such as

This project explores future scenarios involving unpredictable autonomy with everyday connected devices. We explore possibilities for smart devices to be used for playful as well as practical reasons [e.g., 1,2,3,4], and where imprecision, instability, and incompleteness are embraced, or at the very least tolerated. To explore

using machine learning to pattern-match faces, predict meaningful activities, and decide when to send alerts or activate recordings. From these trends, we ask: What else could smart security cameras become—beyond cameras, beyond security devices, and beyond inanimate tools?

Design Metaphors: Robots, Toys, Guardrails, Overrides

Analyses of trends led to divergent exploration of how current smart security cameras could continue to be more than cameras, more than security devices, and more than inanimate tools. From this broad directive, a tacit rule solidified for this exploratory design process: limit ideation to absurd, fanciful, and bizarre proposals. A combinatorial approach proved exceptionally generative, resulting in proposals for indoor security cameras mounted inside cupboards (surprise!), configured with telescopic lenses (for extra creepy surveillance?!), and attached to the end of landline telephone receivers (what might a long, but limited, reach accomplish...?).

One idea intuitively stood out as particularly compelling, for reasons that became clearer as the design process unfolded. This idea was originally framed as the setup for joke: A Nest Cam rides a Roomba into a bar.. The open-ended punchline—to be determined—proved a tantalizing setup to drive an exploratory design process.

Eventually, developing this design proposal led to drawing upon design analogies of robots, toys, guardrails, and manual overrides. Threads of trends explored previously were revived and expanded. The trend toward always-watching and always-listening cameras were broadened to include always-autonomous devices. Explorations of illuminative, decorative, and mood-setting functions of lamp-inspired smart cams were expanded into explorations of playful, social, and reflective applications. And the regulatory functions of curtains and shutoffs were extended to consider the function of guardrails and manual overrides when designing automated and autonomous systems.

Google's Clips

A kid with Clips and Toys

iRobot's Roomba

A cat riding a Roomba

Prototyping Devices Used

The prototypes in this scenario combine two AI-powered devices: A Roomba robotic vacuum cleaner, and a Google Clips hands-free wireless camera. Clips uses AI to take photos it thinks you might want, and Roomba uses AI to clean areas of your home it thinks are dirty. Both invite playful, curious interactions, as captured in the images above.

Concept Evolution

Once the decision was made to move forward and actually implement a version of a Nest Cam riding a Roomba, the first set of refinements made two important design choices. The first key decision was for the camera to be mounted atop the Roomba facing directly up at the ceiling. While this constraint was later relaxed, it represented an important step in sharpening the themes of surprise, unpredictability, and unconventionality within the design

For both logistical and thematic reasons, the second key decision was to augment or replace the battery-less USB-powered Nest Cam with a mobile battery-powered device, thus resolving—regrettably, perhaps—the comical predicament of a roving autonomous robot tethered to a household power outlet. The AI-powered Google Clips camera was eventually chosen to replace the Nest Camera. This route was also chosen partly for logistical reasons, and partly to explore thematic parallels of autonomy between the Roomba and the AI-powered photo decisions of the Google Clips.

The initial concept envisioned a Roomba mounted with a Nest camera pointed straight up at the sky or ceiling...

Camera Mount Form Explorations. Four forerunners emerged as mounting mechanism candidates for attaching the Google Clips camera to the Roomba: a rail, a plate, a tower, and an arm design. Several rounds of rapid prototyping and test runs were conducted implementing these smooth and orthogonal form variants. These form studies were later revisited and expanded to explore variants embodying themes more congruent with the interactive forms and operations of both the Roomba and Clips camera.

Rapid Prototyping and Trials. Prototype trials resulted in two pivotal insights. First, it became clear that initial explorations reflected an implicit search for precision, stability, and completeness. This tacitly reflected themes and sensibilities at work in prior explorations of Wall-to-Wall and Precision Coverage. Second, after multiple crashes and unanticipated events, it was recognized and then appreciated that both the Roomba and Clips were operating according to a shared principle of unpredictable autonomy. Clips captured photos when it decided it should, and the Roomba roved to where it decided it should clean.

Rail iterations. Form studies and test trials.

Final Design: Imprecise, Unstable, Incomplete. Informed by trials and form explorations, the revised concept sought to showcase and support unpredictability, imprecision, instability, and incompleteness. The final design was revised to involve a shaky bumper-mounted plate, an imprecise mounting rail, and an unstable tail mount.

The product collage kit allows different mounting options. The tail configuration sways when it collides with a wall or object. The rail configuration enforces non-orthogonal camera views.

Clips Mounted Roomba Kit

A mounting kit was designed to support two configurations: rail mounting and tail mounting. The rail was designed with a combination of non-smooth curves and angular bends. The rail was intentionally designed to disallow the most straightforward orthogonal mounting positions—straight forward, straight backward, straight up, straight to either side. The tail was designed at a height of approximately 1 meter (3.2 feet). This height was found to achieve a satisfactory swaying back and forth each time the Roomba strikes a wall or objects and turns to traverse elsewhere. The height also achieved a slight personifying effects imbuing the contraption with a distinct personality. At a height of 1 meter, the device no longer scurries, but rather bumbles about. At roughly the height of a small child, the tail version appears to stand upright, vaguely resembling an arthropod. Our design work aligns with Hoffman and Ju insights that the expressive power of a robot's movement is a crucial yet often overlooked consideration [5, p. 89], and Forlizzi and DiSalvo insights concerning the important of the aesthetic, symbolic and emotional aspects of domestic robots [4, p. 264]

The Need for Overrides and Guardrails

The Roomba is designed with an intuitive manual human override: simply pick the Roomba up into the air, either by grasping the sides or the built-in recessed handle. Clips is similarly designed with manual overrides: twist the lens to turn on/off, press the button to manually (rather than algorithmically) take a photo. Many Roomba users arrange furniture and objects to restrict the movement of the device, and prevent it from accessing certain rooms or areas.

A consequence of our unpredictability-embracing prototype above is that it occasionally malfunctions due to collisions. Certain modifications could address this: a spring-loaded tail, a set of safety clearance bars or rails, or a protective case and safety cord—in case of accidental disconnection. Mechanisms for transitions from manual to automated controls are also important to consider [e.g., 7]. With these Roomba+Clips prototypes, these risks are designed to be embraced, or at least tolerated.

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