VIRTUAL AGENTS

HCI Capstone 2016

Research Report

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EXECUTIVE SUMMARY

The educational tech sphere is one that has grown in prominence, yet remains undefined in many ways. The Articulab at Carnegie Mellon is attempting to uncover some of these features of childhood education, as well as how technology can be implemented to better serve these purposes. The SCIPR project - a multi-year endeavor headed by Justine Cassell - is a breaking attempt at bridging the gap between virtual agents and education, and the physical world. By investigating how virtual agents can extend beyond their digital confines to affect their environment in tangible ways, SCIPR seeks to understand how collaboration and curiosity in learning can be improved.

While our project is focused on building a foundation for this physical intervention to occur, our research aims to understand the problem space more holistically. That is, we seek to understand more about the collaborative educational space as well as mixed reality tech. By exploring available technology options, we hope to understand realistic and feasible ways to affect physical environments. Furthermore, by augmenting this knowledge with an understanding of successful collaborative environments, we aim to produce a prototype that is extendable and workable for future development within the SCIPR initiative.

With the conclusion of our initial research, we hope to identify technology that is feasible for our team to build and relevant to SCIPR's objectives.

RESEARCH GOALS

- Discover design principles to guide the interactions and character of our virtual agent.
- Identify the differences & similarities between how robots and ECA's interact with humans.
- Find and compare mixed reality technologies.
- Understand how to appropriately use technology to interact physically with the world.
- Find and compare actuation technologies that can have a physical impact on the world.

METHODS

Literature review

We performed an initial literature review to gain a broad knowledge the project space in order to inform future brainstorming and ideation. We gathered and analyzed information gleaned from external research and studies. We focused on the following topics to obtain a more holistic awareness of the nature of our project: robotics and technology, computer vision, artificial intelligence, augmented reality, children's perceptions of robots, trust, mixed-reality agents (MiRAs), virtual agents in games, tangible toys, social interaction in play, and technology in education.

The visual appearance of an agent can greatly vary the experience of human collaborators (e.g. humanoid, anthropomorphic). The addition of a screen with a virtual agent to a robot can drastically increase feelings of embodiment. Virtual entities have been produced successfully in games in non-literal ways such as controlling the environment.

Videos

To gain a better understanding of the context we are designing for, we watched videos from research studies conducted by our client. We listed and diagrammed movements and actions participants took in order to build a Rube Goldberg Machine in a collaborative social tabletop environment. Careful observation revealed frequently repeated behaviors, breakdowns in social collaboration, curious behaviors and learning strategies children use.

The agent's sensing capabilities are as important as physical embodiment. The agent's actions should be similar to the natural behavior children already experience in a collaborative learning environment. Curiosity and learning comes in many forms depending on the child.

Expert Interviews

To get insight into the different ways in which we can give our virtual agent embodiment, we conducted two expert interviews. These expert interviews were unstructured and lasted 30 minutes each. We interviewed one professor in the Robotics Institute and one PhD student in the Robotics Institute. We selected questions that were specific to each interviewee. Our questions involved more general questions such as possible alternatives to robotic arms for embodiment, as well as more interviewee-specific.

Our interview with Laura led to some possible technology solutions for visualization such as a Kinect. She also helped us focus on the sensing part of virtual agent embodiment and suggested technology solutions such as a procam system and RFID or QR codes. Lastly, she pointed out that a humanoid solution was not necessary to create effective social interactions between the child and the agent.

Our interview with Chris Atkeson led us to think more seriously about adopting a non-3D solution for our virtual agent's embodiment. He told us that it was difficult to implement something that could stack things in a 3D environment and that a lot of personality can come from sound (more specifically music and voice).

Competitive Analysis

To better understand the different technological approaches possible we compared them across a number of criteria. These criteria fit into two broad categories, internal development and user experience. Our approaches were split into their overall functions- visualization, actuation and sensing. Using results from our literature review and expert interview we were able to evaluate each approach from a spectrum of low to high.

We found that we will need to combine approaches to have a holistic physical embodiment. By working with our client we found out which attributes were most important to the project.

Affinity Diagram

In order to synthesize our research and draw out guiding design principles, we made an affinity diagram of all of our research. In order to do this we all took time individually to write out all of our findings on yellow sticky notes. We then individually began moving these insights around on a whiteboard, clumping them together with alike findings. Once the groupings became clear we titled them with overarching design principle and take-away phrases. Finally, we grouped those findings into categories for easy reference.

Our finding that “indirect interactions are viable” and “the agent is different from child” led to the supergroup “Embody Agent through Proxy”.

“Multi-modular embodiment”, “combine physical and digital embodiment”, and “Tangible Interactions” led to the supergroup “Disperse Agent throughout Mediums”.

“You can do a lot with sound” and “Retain anthropomorphic aspects of agent to improve rapport” led to the supergroup “Create Character”.

Finally, “Different kids interact differently”, “Novelty inspires curiosity”, and “The agent should attract attention” led to the supergroup “Engage the children”.

FINDINGS

Agent embodiment should retain some anthropomorphic attributes but does not necessarily need to be humanoid.

Just like Pixar creates engaging and relatable characters by interjecting anthropomorphic characteristics into inanimate objects, we can leverage a child's innate connection to anthropomorphic forms in our agent design.

We have to strike a balance with how we use anthropomorphic elements in the agent design. If our designs become more humanoid rather than anthropomorphic, we will struggle with uncanney valley and numerous technical problems simply trying to reflect realistic humanoid actions. With that said, without enough anthropomorphic elements, the character will become unrelatable to the children. The goal is to properly leverage the differences between the agent and the child to create the best experience.

Symbolic physical embodiment could be as effective as having a tangible, physical presence

Both our literature review and expert interviews uncovered a variety of approaches to realizing a virtual agent's influence in the real world. In particular, that entities can establish a presence without literally being present in an environment.

An example is the use of a proxy: a stand-in for a virtual agent in the real world. A proxy may be able to move, tangibly affect the world, and vocalize in a way that is suggestive of a virtual agent's intent. Similarly, a virtual agent may be able to demonstrate embodiment by controlling some aspect of an environment (e.g. controlling the lights on a table). This approach varies from a more literal interpretation of physical embodiment, in a which it may be interpreted that an agent posses human autonomy (hands, limbs, etc.). By experimenting with sound, visuals, and relationships between agents and other objects, embodiment can be improved.

Agent’s sensing capabilities are as important as physical embodiment

The agent not only needs to be able to affect the world around it, but also sense environment as well. In terms of physical capability this is essential, as the agent will be able to detect the movements and actions of the children they interact with and react accordingly. This blends well with one of the SCIPR project’s overarching goals to identify and encourage curiosity. Adding physical sensing will augment the ArticuLab’s current capability of analyzing through voice and video information.

Embodiment for 3D built environment will be different than for 2D environments.

With a 3D tabletop environment, it is best to focus on directing the attention of children as opposed to focusing on object manipulation. Actuation options will be limited due to constraints of robotics and sensing technology. One approach to avoid robotics challenges is to integrate actuation into the parts and pieces children will be interacting with on the table. In a 2D built environment, object manipulation will be more viable but poses challenges in depth of activities children can engage in.

Agent should adopt natural behavior and expressions from the kids

To increase the overall rapport between the agent and the kids, we should incorporate expressions and behaviors that mirror the children to foster a more natural connection between them.

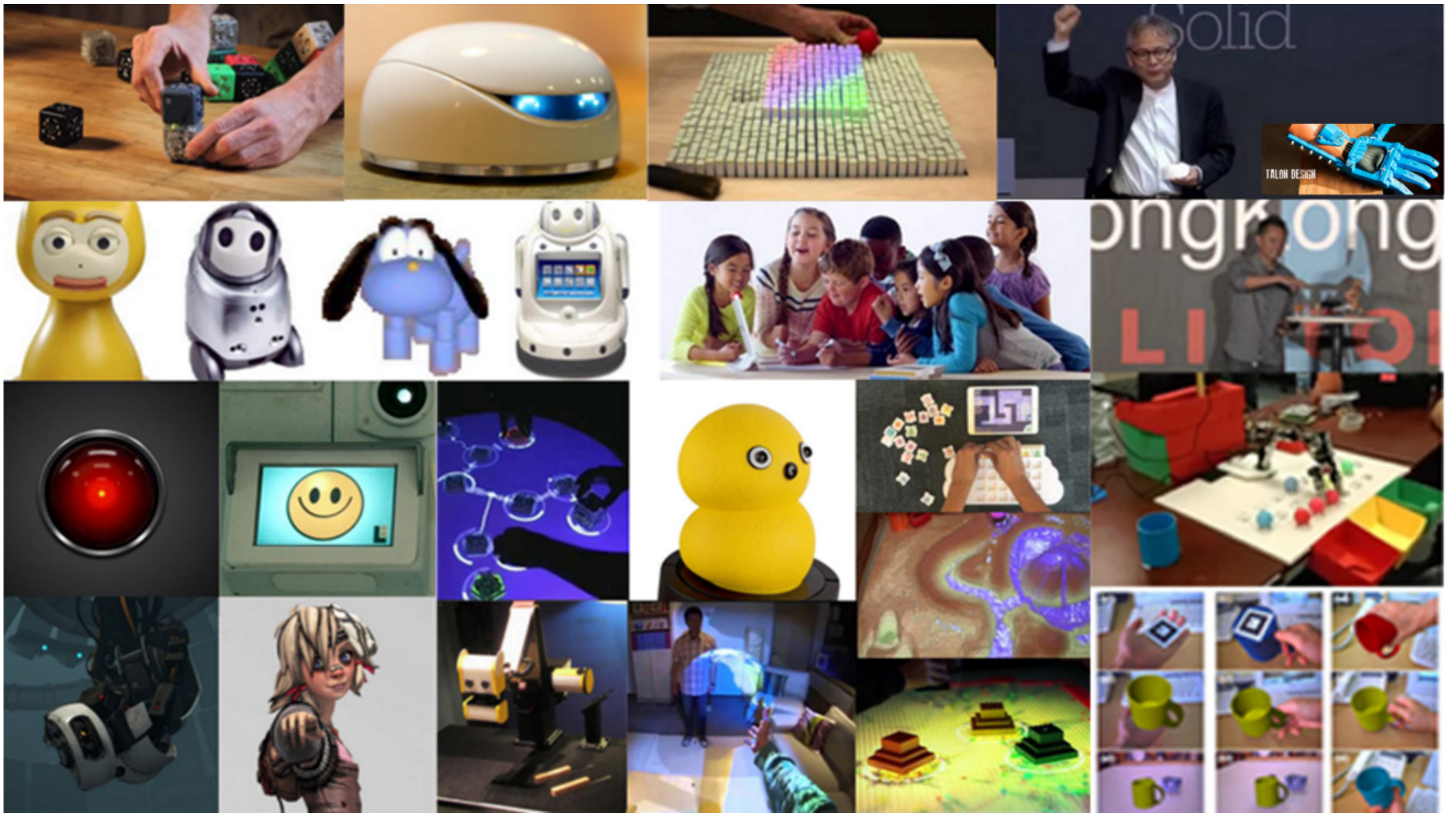
NEXT STEPS

- Brainstorm approaches and scenarios
- Incorporate technologies from competitive analysis
- Test low-fi prototypes

APPENDIX

Literature Review

Visual Diagram



Video Analysis

Expert Interviews
Interviewees

Laura Herlant
PhD student in Robotics Institute who studies robot object manipulation, HRI and HCI.

Chris Atkeson
Professor in Robotics Institute who specializes in assistive robotics, HRI, and HCI.

Competitive Analysis

Criteria	*Approach*	Internal Development				User Experience			
		Extendability (Adaptive to different activities) (3)	Economic Viability (3)	Ease for us to build (2)	Compatiblity w/ current system (1)	**Agent's ability to interact with physical world (3)**	**Child's ability to interact with physical world while also using technology (3)**	Works w/ multiple users (2)	Ability to show agent's expressiveness (1)
Digital Visualization									
	Webcam Large Screen AR (single screen augmentation / mirroring)	**High**	**High**	High	High	N/A	**High**	High	High
	iPad/iPhone AR (Individual "windows" into virtual world)	**High**	Low	High	High	N/A	**Medium**	High	High
	Projection	**High**	**High**	Medium*	High	N/A	**High**	Medium	High
	Tangible Tabletop Interface (Multi-touch tabletop)	**High**	Low	Low	Medium	N/A	**High**	High	High
Actuation									
	3D printed robotic hand	**Medium**	Low	Low	Low	**Medium**	N/A	N/A	Medium
	Magnets	**Medium**	**High**	Medium	Low	**Medium**	N/A	N/A	Low
	Tangible Output Widgets (arduino-based output)	Low	**Medium**	Medium	Medium	**Medium - High**	N/A	N/A	Low
Proxy									
	Robotic Toy/ Virtual Agent's pet	**Medium**	**Medium**	Medium	Low	**High**	N/A	N/A	High

Criteria		**Economic Viability (3)**	**Extendability (3)**	**Ease for us to build (2)**	**How much it can capture/sense (2)**	**Work w/ multiple users (2)**
Sensing						
	Template-based tracking (Marker Based)	**High**	**Medium**	High	Medium	High
	3D Object Tracking	**Medium**	**High**	Low	High	High
	Tangible Input Widgets (arduino-based input)	**Medium**	**High**	Medium	Medium	High
	RFID	**High**	**Medium**	Medium	Medium	High
	Kinect	**Medium**	**High**	Medium	High	High
	Capacitive Touch Surface					
	Magnetic Field Sensor					

Affinity Diagram