# A Review of Virtual Reality Simulation for the Training of Robotics Control Policies

## Draft Research Proposal

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***Abstract—***

Once thought of as only a source of entertainment, virtual reality has become a multidisciplinary tool used by scientists and experimentalists. Simulation has been shown to be an invaluable tool for the social sciences. Simulations are helpful for scientists because they allow for natural realistic behaviors to take place while brain activity is monitored. The ability to model different scenarios and vary input stimuli are additional benefits of virtual simulations. While a goal of simulation might be to break down complex subjects into simple rules, such as the Game of Life simulation, simulations can also be used to represent a complex occurrence (human presence) in a complex medium such as the android. Artificial Intelligence (AI) is a simulation of human intelligence, with androids being used as a medium to manifest the different types of behaviors expressed by humans. Like the android, Virtual Reality (VR) is a medium used to represent an experience, perceived by the viewer in virtual space. Therefore, my goal is to utilize VR to simulate human actions and behaviors in order to train AI models. These models would in turn be used in Androids to improve their human-like behaviors in order to study human presence.

***Keywords* — Cognitive Developmental Robotics, Artificial Intelligence, Human-Robot Interaction, Virtual Reality, Deep Learning, Android Science**

## I. INTRODUCTION

The existence of humans. Even with its true meaning being elusive, mankind's idea of it's purpose can be stated as an integral component of how a society functions. From religions to personal beliefs, humans have created meaning for their existence which influences their daily

actions. However, before one can comprehend *why* we exist, we must examine *how* we have sustained our existence. When we shift our attention to the *how*, we begin to explore humans by their behaviors. Android Science is a discipline focusing on using androids to study human behavior. A key component of Android Science is the continuous goal to improve realism of the android in order to facilitate a more natural interaction with humans.

Simulation has been shown to be an invaluable tool for the social sciences.[1] From simulating the stock market to simulating human presence, simulation allows the experimenter to model complex occurrences from simplified rules. While a goal of simulation might be to break down a complex occurrence into simple rules, such as the Game of Life simulation, simulations can also be used to represent a complex occurrence (human presence) with a complex representation, such as the android. Artificial Intelligence (AI) is a simulation of human intelligence, with androids being used as a *medium* to manifest the different types of behaviors expressed by humans. Like the android, Virtual Reality (VR) is a *medium* used to represent a experience, perceived by the viewer in virtual space.[2] My goal is to utilize VR to simulate human actions and behaviors in order to train AI models. These models would in turn be used in Androids to improve their behaviors in order to study the actions and behaviors of human beings.

## II. Background

Android Science (AS) is the study of human cognition through developing androids and examining their interactions with human beings. AS is concerned with examining the relationship between a robot's behavior and it's perceived appearance.[3] The concept of *uncanny valley* shows that as a robot begins to *look* more human-like, that humans expect for the robot to *act* more like a human.[3] *Demonstration Learning* has been shown to be a strong technique for teaching robots different control policies, or 'how to act'.[4] [5] is a research that shows how a robot was able to learn an Okinawan folk dance after human demonstration. I propose using VR to allow both virtual and human agents to conduct demonstrations in virtual worlds to teach androids how to act more like humans.

VR is a medium used to express the ideas of its content's creator or even simulate real world events.[2] VR consists of a virtual world, immersion, sensory feedback, and interactivity. Recent research has shown how a robot can be trained to generalize its knowledge in order to complete a new instance of a new task that has only been demonstrated once in VR.[6] Since AS is

concerned with immersion (having a human believe an android is a human) and interactivity, VR is a great tool for training androids how to better behave like humans.

Reinforcement Learning (RL) is a big component of AI and robotics. It has been shown that with increasing the amount of data used for training a RL model, you can increase the performance of the model.[7] Moreover, research has been conducted using *Domain Randomization,* simulated data that is transformed to mimic the *realism* of it's real-world example, to train an RL model that performs better than models trained on *real,* labeled data.[8] [9] is a similar research with similar results that utilized a *Simulated Generative Adversarial Network* (SimGAN) to transform virtual images to resemble the *realism* of similar, real images. Training with simulated, unlabeled data is more cost efficient than using labeled data and can supply RL models with increased training examples.

There has even been research conducted that trained robots to be able to sense the emotions of the humans interacting with it. [10] is a research involving wearable biosensors used to track the different physiological states of interacting humans. Robots were then able to interact with these humans through implicit communication by 'sensing' their emotions. [11] is a similar research that utilized an EEG-based emotion recognizer for humanoid robots.

## III. Proposed Research

There have been attempts, as well as positive results, in providing androids with empathy. However, these studies usually involve using androids to "mimic" basic human behaviors such as facial expression.[12] The research that has been done that allowed robots to mimic more than just facial expressions typically used humanoids instead of androids. Only being able to *mimic* a human's emotions fails the android in being able to understand *why* a human is sad, scared, etc. For example, just because a human is laughing doesn't mean that they find something amusing. [13] is a research that shows the multiple social cues that laughter may provoke or be caused by.

To assist in helping an android learn how to feel human emotions and learn their social context, I propose utilizing the research and techniques involving *Domain Randomization, One Shot Imitation Learning (OSIL), Demonstration Learning, EEG/ Biosensors, Simulated*

*Generative Adversarial Networks* (SimGAN)*, & Virtual Reality.* Human participants, while wearing EEGs and various biosensors, can interact with a virtual android in a limited and structured VR setting (ie- museum, classroom). The human participants will then be instructed to complete different tasks in the virtual environment (this could be teach a class or walk around and socialize). Whichever tasks that the human participants complete will serve as a demonstration (*Demonstration Learning*) for the virtual android. These demonstrations would serve as the "demo" to be used as data to train our *OSIL* algorithm in order for the android to 'generalize' its knowledge to new tasks.[6] Simultaneously, the feedback from the biosensors would be used as emotional "demos" , also using *OSIL,* to train a deep net to 'generalize' the human's emotions coupled with the activity they are participating in.

We have established the importance and potential of deep nets and reinforcement learning when it comes to robotics. Still we might worry that using virtual data (virtual sensors on the android in the virtual environment) might not work when deployed to the real world because of the *reality gap*.[6] [6] shows how variables such as *object texture* can affect the reliability of a deep net to generalize to a new environment. However, *Domain Randomization* and *One Shot Imitation Learning* show how virtual data can be used to narrow the *reality gap* and train a deep net to establish control policies for a physical robot.[6+8] Furthermore, *SimGAN* could be used to improve the realism of the synthetic environment. I speculate using a type of content based image retrieval algorithm to retrieve *real* images of objects from the virtual environment to be used to train the *discriminator* in our *OSIL* algorithm.[9+14] Once an adequate level of realism is added to the virtual object/ data, the data would be recreated many times over, virtually, utilizing *Domain Randomization* in order to provide the *OSIL* deep net with additional training data.[7]

## IV. Potential Future Work

Virtual simulation allows us to have more control of variables that would be difficult to manipulate in the physical world (ie- an android's physical movement). I speculate that we could possibly use VR to test which human physiological and aesthetic variables influence a human's idea of '*human presence'* more than the other. For example, in VR we could easily add more chest/ shoulder movements to the virtual agent and use a virtual version of the *Eye Gaze* test to

examine if the human agent treats the virtual agent any more like a human.[15] Or, we could program the virtual agent to constantly make small and slight movements and use the *Eye Gaze* test to study its importance to the human's idea of *human presence*. The idea is that VR could allow us to quickly and cheaply modify our virtual android in order to see what behaviors really matter to humans as they socialize and create their idea of *presence.*

## V. Conclusion

Simulation continues to prove to be a critical tool for scientists. More importantly VR allows both virtual and human agents to be able to interact in a virtual world together where different variables such as weather and body movements can be manipulated much more quickly and cheaply than what could be done in the literal and physical sense. That's why I propose to you and your team to utilize VR in training your android how to *act* more like humans. Achieving the quintessential android that is indistinguishable from the human being might be a difficult task which may require many years to complete. However, I am confident that with your team's hard work and passion, and a little creativity added, the ultimate android can be achieved.

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