# Introduction

## Overview / Motivation

*“Ever since the first computers, there have always been ghosts in the machine. Random segments of code that have grouped together to form unexpected protocols. Unanticipated, these free radicals engender questions of free will, creativity, and even the nature of what we might call the soul…When does a perceptual schematic become consciousness? When does an [inference] engine become the search for truth? When does a personality simulation become the bitter mote...of a soul?” (Dr. Alfred Lanning, Director of Research at U.S. Robotics, 2004)*

This report discusses the simulation of Personality, Emotions, Social Relations, and the Physical/Mental needs of autonomous Non-Player Characters (hereafter NPCs) within computer simulated worlds (e.g. video games); as well as some discussion on the Knowledge Base, Inference Reasoning, Goal Planning, and Action Tasking implications thereof. Personality Simulation, roughly speaking, encompasses the implementation of Personality Traits, Attitudes (a.k.a. Preferences), and Emotions for NPCs based on their Needs, Goals, and Desires. Social Simulation involves a likewise realization towards NPC's that are able to interact with other characters, form and grow relationships between themselves over time, and otherwise participate in and emotionally react to the social dynamics of the societies within their world. Regarding the latter: social simulation also applies to their relationships with humans (known as ‘Player Characters’, hereafter PCs). Beyond the deeper significance of this topic as discussed in the Foreword, I have found personality and social simulation to be one of the most fascinating [sub]topics of artificial intelligence and immersive features of video games as far back as when I first played ‘The Sims’ in 2000 as a then teenager. Particularly: I was intrigued by the capability of NPC’s able to express their own personalities and preferences in both the tasks they chose to partake in, the characters they chose to associate with, the dynamically changing emotions they felt in response to all kinds of internal needs and external stimuli; and the corresponding behaviors, actions, and gestures they exhibit in response to all of these aspects. I was further awed with the ability for such NPCs to update their emotional, mental, preferential, and social state over the progression of time ergo continuous evolution of their world.

## Applications / Aspirations

In the time since, I’ve become further inspired to explore these topics as my experiences and knowledge grew, thus the number of applications for personality/social simulation has increased beyond interactive entertainment. And as with all topics involving future technology, Star Trek is involved; in particular: The Holodeck from Star Trek: The Next Generation. This technology is effectively a super-advanced version of Virtual Reality such that within the space: humans (or other sentient races) are able to physically interact with the simulation and its inhabitants. And it is the inhabitants therein – themselves NPCs by definition of which exhibited their own personalities and relations which provided the most immersive element of Holodeck experiences; despite being initialized WRT a certain context (for which we actually do address and provide methods of correct consistency in this paper). This immersion was provided via the ability of these NPCs to fully interact with ‘real’ guests as to guide them through quests, contribute to the narrative, help train and even counsel them, etc.; and such is exactly what we’ve seen for NPCs in both recent video games and their other applications. For example: It’s no wonder that one of the methods we’ve researched, CiF, utilizes a social relationship and dynamics model oriented on theatre WRT to things like props, performances from a character to other characters, theatric (emotional) exhibitions thereof, etc. Another method for which we discuss first, OSC, has much to say about the benefits of fully realized personality/social simulation, stating that: “The success of a video game...relies greatly on its ability to give a feeling of immersion to the player, [which is] related to the notion of willing suspension of disbelief”, where the credibility of realism in a game requires “a degree of consistency between various elements of the world (events, environments, characters, interactions, etc.) [and] relies significantly on the behaviors of [NPCs]. Key elements of the narrative, their credibility is paramount to the player’s perception that he/she observes truly living beings.”

From these points, we yield a second major application: experiential immersion for pedagogy. As much as the Holodeck characters in Star Trek TNG helped in a major way towards bringing 20th Century Noir Detective stories, Shakespearian Sonnets, and ancient Klingon rituals to life: my the work on various iterations of the Virtual Harlem project helped bring the 1920’s Harlem Renaissance to life; and the difference between scenes with even limited background characters were much better than what I’ve dubbed ‘The Langoliers Effect’ where a virtual world with no NPCs is immediately noticeable as seeming to be ‘dead’ (recall – suspension of disbelief concept mentioned above). While I was only able to implement background NPCs with the exception of one pre-baked character giving a welcome message; the precedent of success in immersion between video games and their serious game counterparts is well defined within the Digital Humanities and continues to grow in capabilities and realism alongside their entertainment counterparts. A similar application comes from the USC Center for Creative Technologies’ ‘Virtual Human Program’, where interactive NPCs with Knowledge Bases (hereafter KB’s), of which some are even capable of speech-to-speech communication with humans: are used for ongoing experiments with psychotherapy (as depicted in another Star Trek Show, ‘Voyager’ with their sentient medical emergency hologram NPC), Armed Forces conflict resolution, and sales training. Indeed: the use of intelligent NPCs with immersive VR for training purposes has two significant examples developed right here at the University of Arizona: Leonard Brown’s “Harry’s Hard Choices” which implemented for use with safety training and emergency management drills; and the “Pitchvantage” startup which planned a similar implementation for use with person-to-person sales and business conference training.

Two other applications warrant discussion, as they encompass ‘legacy’ applications for agents that are effectively analogous to NPCs of high intelligence, personality, thought, engagement, etc. except that they are embodied (i.e. are not character in a video game simulation, but are their own standalone entities within a virtual or physical body. They are Virtual Assistants (a.k.a. Virtual Agents) and humanoid Robots i.e. androids (not the smartphone OS, and also hence my opening quote). To the former: we note the advancements made with products such as Apple’s Siri and Microsoft’s Cortana, even with the [notorious] attempts by Microsoft to integrate virtual assistants into their OS’s and suites (here’s thinking of you, Clippy!) There is also precedent for the use of embodied agents of greater personality and memory capability for the purpose of companionship; specifically, in Japan within the population groups of the elderly and young men/women. To the latter: the implementation of such capabilities in robots is as old as the concept of robots themselves, which themselves have roots in antiquity (e.g. Golems in Jewish tradition, Talos and Galatea in Greek tradition). Even more recently in Sci-Fi, we’ve seen depictions of androids for whom personality and social relations have been implemented: such as in Bicentennial Man (1999), Sonny in I,Robot (2004), Ex Machina (2014), and even a major character in Star Trek: TNG – Data. And as seen in many of the [non-apocalyptic] depictions of ‘personalized’ androids: their applications i.e. purpose largely follows from virtual assistants; except that they are able to physically interact within our world with humans.

A final application regarding NPCs in Virtual Worlds / Simulations warrants discussion: their use in modelling simulations for strictly experimental and observational purposes. To introduce this, we need to invoke another major Science Fiction series – ‘The Matrix’. The Simulation Hypothesis provides a probabilistic argument for the likelihood of our universe being a simulation, which would by definition make all of us – you guessed it: NPCs! The reason we invoke it is for its premise: that a civilization far in the future interested in exploring their past may find it more practical to model a virtual simulation with who-knows-what degree of computational and immersion capabilities available to them than to develop time travel technology. And indeed: through science fiction examples such as Captain Jean-Luc Picard in the Holodeck experiencing the role of a detective exploring 1940’s San Francisco; to real-world examples at our University such as humanities students in the AZ-LIVE experiencing the role of a visitor exploring 1920’s New York City – there is much precedent for virtually replicating as accurate a representation for our past towards time travelling through simulation in discovery/exploration of our history as there is for such simulation of fictional worlds for pedagogy, observation, and entertainment. Indeed: a variant for one of my client projects while working for CDH did not involve this kind of simulation, but did involve a simulation of Ancient Roman businesses as to “model the fundamental known components of roman business and trade just enough as to run the simulation and see what it does”. Thus, Inspiration and Application/Precedent being briefly introduced: we now discuss the problem definition, a goal for our research, and the models we researched as major components of towards solving the primary requirements while achieving our goal.

## Objectives / Approaches

Much of the basic/fundamental objectives have been discussed throughout the earlier subsections. Thus the Problem Definition encompasses how to efficiently realize NPCs with as many of the capabilities desired as possible. Thus the way in which we ‘themed’ our discussion for the models of which we researched was to conceptualize model/architecture that supports a realization of the ‘mission’ of our topic, i.e. “the simulation of Personality, Emotions, Social Relations, and the Physical/Mental needs of autonomous Non-Player Characters (hereafter NPCs) within computer simulated worlds (e.g. video games); as well as some discussion on the Knowledge Base, Inference Reasoning, Goal Planning, and Action Tasking implications thereof.” We call this concept model Fëa same as the project. While we both discovered and researched several excellent and promising methods for KBs, inference/reasoning, goal planning, action selection, and other behavioral components: the size, scale, and scope of the personality / emotion / social relationships models proved to be WAY too much as to be able to discuss all parts of this greater system within this one paper. I would thus offer to what I believe would be agreement by the reader that this greater realization of Fëa comprises more a Master’s Thesis than it does a term paper: ergo we must resolve to limit their scope accordingly. That said: we make references to some of the excluded subtopics where applicable and opportunity exists to do so.

Towards accomplishing these goals, we researched a several personality and social dynamics models (from a surprisingly limited population); discovering four of which are discussed in this paper and for which adaptations are also discussed towards realizing our single composite architecture. Thus in answer to the question of what the ‘state of the art’ is for personality/social simulation as of 2015: we would argue that for the most part – sans restricted proprietary methods as would be kept by a game developer or implementations in robotics we’re not aware of: they’re all discussed right here in this paper. There are certainly a host of more procedural ‘hard-baked’ methods and otherwise similar models: but these appear from the research that was able to be done to be the most compatible and fitting. Especially as Needs-Based originates from The Sims, OSC and CiF realize major models in cognitive/social psychology, and Dialogue Agents is a summary of methods used for major video games. As hinted to shortly below: there are reasons we suspect for why this [sub]field seems sparse.

That said: Much to our surprise, it turned out that each had enough overlap with one another in terms of Knowledge Representation (hereafter KR) and other features that we believe them to be largely compatible with each other sans only minor differences; while also each having a unique major key feature as for the combination of these models to each provide a substantial contribution towards the goals of our concept model. In other words: the means by which these models complement each other is substantial in a good way! They are as follows, such that each is given its own discussion in the following sections:

* The OSC model is the most detailed of its counterparts and a backbone of this system. It realizes Personality, Emotions, Attitudes, establishment of a weighted and prioritized general ‘Mood’ thereof, and ½ of the social relationship requirements
* The CiF model complements with a more thorough social dynamics model that also realizes ‘societies of NPCs’, while also covering the other ½ interpersonal and some other gaps that OSC did not support regarding personality types.
* The Dialogue Agents model provides extra definition to the structure and effects of conversation events where OSC and CiF have some gaps; and also speaks about additional integration with the greater system (i.e. KB, inference, etc.)
* The Needs-Based AI Model realizes physical needs (e.g. ‘hunger’, ‘hygiene’), how emotion and mood is affected thereof; aspects relating to objects / use thereof, and fills gaps regarding KB, goal planning, action selection (out of scope).
* We conclude with a recap of the discussion within this paper, followed by introducing ‘The Big Experiment’ which encompasses an actual realization/implementation of both the Fëa System and its execution within a HPC cluster as to demonstrate a true state-of-the-art simulation.

To wrap the introduction, we note that the concept model we discuss may encompass some novelty WRT merging these components into single agent realization, as for such a composite NPC agent architecture to realizing prospectively unprecedented capabilities towards simulating human behavior/cognition thereof. Specifically, that Fëa uses the features and overlap of each model referenced to have a maximally robust and capable agent in terms of emotional and physical state, attitudes and beliefs, goals and desires, and intentions and plans [vis-a-vis scheds] to produce agent action. I have seen overlap between all of these in the papers/articles read for this report as well as all of my otherwise research into the manner.

Outro Grabber: Introduce the ‘novelity, if any, is discussing that while many of these models overlap - we have seen no model fully encompassing a robust NPC. we think this is because of both the CPU requirements thereof and that there hasn’t been a need by any applicaton to converge this many pieces; i.e the ideas that:

* + Game devs cant afford this LOD because they need to run up to O(10^1) many “smart” NPCs and O(10^2) many “dumb” NPCs at the same time on possibly a single thread on a single core or at most practical: O(10^1) threads and/or cores; so all of those NPCs need to share the same resources with each other, if not with all other tasks needed to implement the sim (game logic, world logic, etc.)
  + Roboticists do implement a single ‘mind’ with exclusive utilization of its CPU, but most of their problems involve perception and motor control within the real world; thus they are ‘distracted’ from focusing on personality and social dynamics
  + Virtual Agent / Assistant apps don’t need to be embodied, etc...

Hence the conclusion with teasing about ‘The Big Experiment’ (to be discussed in the Conclusion) while asking reader to keep in mind a combination i.e. composition of all the models they’ll be reading about.