Why Humanoids?

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1 Introduction

Throughout its history, robotics research and arguably, the ultimate goal of building an artificial human, has suffered many failings along with some surprising successes. Our fascination with creating humanoids dates as far back as early mythology such as the Golem in ancient Jewish legend, to Leonardo da Vinci's wooden man based on the Vitruvian canon (c. 1495), Jacques de Vaucanson's flute and tabor players (c. 1735), and Henri Maillardet's writing and drawing figure (c. 1815). Automata based on the human form draw on people's expectations and projections in order for the illusion to work. However, the human form requires the automata to have behaviours to match, a significant engineering challenge.

Throughout different technological eras, our fixation on building humanoids has not shifted despite the engineering difficulties. Yet, the persistence of the difficulty in attaining this goal brings us to question if there is an advantage of building humanoids. Why should we want to in the first place? The history of successful humanoid design has been limited. What is more apparent is its lack of success.

2 The 100 Year Error

Perhaps one of the most famous examples of a humanoid form which has been unsuccessful is Thomas Edison's 19th century "Talking Doll". Edison decided to take the established formula of a doll and augment it with one of the most advanced devices of the day, the phonograph. Now the baby doll could talk! Edison invested heavily in a manufacturing line which could then mass produce this revolutionary doll and bring it to children everywhere. It failed however and was only marketed for a few weeks in 1890. Arguments for why the doll did not succeed range from the technology being too young with only a limited vocabulary available, to the doll being too heavy with the mechanisms installed. Possibly the most revealing insight is the story of a child having seen the phonograph mounted in the body of the doll and being surprised asking how could it digest its food? The reason for its failure can be attributed to it being one step towards removing the need for one of the most fundamentally necessary elements between the child and the doll, imagination. In using only the very minimal feature of an anthropomorphic form, a child's imagination builds a whole world around this. Incorporating a speech device reduces the dolls "language" to a finite set of possibilities. It removes imagination from what the doll can "say". When we see the humanoid form, we create expectations about its physical and social behaviours that become more and more difficult to manage with increasing anthropomorphic resolution. This difficulty which leads to the conclusion that the more anthropomorphic does not necessarily mean better, is captured in what has been referred to as Mori's "Uncanny Valley" [1]. When a humanoid's behaviour explicitly conflicts with our expectations drawn from its form, the illusion fails. More recently, approximately 100 years after the failure of Edison's "Talking Doll", a baby doll which incorporates such technological advances as embedded speech generation, models of emotion, and servomotors was not successful as expected. "My Real Baby", a robotic baby doll developed in collaboration between Hasbro and iRobot Corp., repeats the same error. We easily give "life" to something that doesn't ask too loudly to be alive (a simple doll), rather than when it demands to be alive.

3 Away from the Human

Reviewing the forms of robots through history, the most successful ones appear to be not humanoid nor do they replicate humanlike abilities. We see this in 1961 when the robot was first employed in practical use. UNIMATE, the first industrial robot which began work at General Motors, was nothing like a human. Today, the population of such industrial robots is estimated to be close to one million machines (according to "World Robotics 2000") with their success firmly grounded in their ability to perform tasks that humans are inherently not good at. While not renowned for its ability to adapt, improvise, or draw reliable conclusions based on incomplete information, an industrial robot's precision, speed, and strength are what ensures its success. Today's automated factories are even designed solely for robot efficiency with limited concessions to a human-centered environmental layout.

With the development of robot technologies, robots have taken jobs previously occupied by people, jobs that are generally classified as dirty, dangerous, difficult, or dull, resulting in companies producing goods of higher quality, with lower costs, and increased profits. The primary use of robots is unskilled tasks, with a consequent increase in skilled people for the installation and maintenance of the replacement robots. By removing people from dangerous environments, the insurance costs previously dealing with this issue, have also reduced. There are many examples outside the factory of robots displacing humans. The U.S. Predator drone plane and cruise missile technologies are examples of highly sophisticated artificial intelligence controlled robotic devices. It has been proposed that such missiles, with their high-tech guidance systems, dramatically reduce civilian casualties compared with other bombing campaigns in history. Similarly, removing the human as a constraint in the system allows more flexibility in the size, speed and force possible in, for example, miniaturized surveillance and ultra fast missiles. There has been limited success of surveillance robots based on replicating the human security guard. On other hand, by embedding the intelligence in the building or area itself through advanced surveillance systems, a more robust system could result. Similarly, de-mining robot strategies ranges from relatively small disposable devices that activate the mine and are destroyed, probing devices which try to locate mines for future defusing, to large robots that trample the mines and absorb the explosions with minimal damage, all retain little reference to the human function and form.

In addition to the destructive element, robots have successfully aided surgeons worldwide in operations on humans. In addition to robotic arms, haptic feedback has helped the doctor feel the tension when pushing on blood vessels or tendons. This tele-operation helps overcome the constraints of distance and urgency. Robotic aids include magnifying operated areas, virtual reality visualization techniques and highly sensitive haptic feedback. A key feature in these robotic aids is their augmentation of the doctor's abilities. Many other examples exist where robots are employed for specific tasks which exploit a machine's inherent capabilities (rather than be constrained by them) such as hazardous environments, space exploration, nuclear environments, and deep sea exploration.

4 The Reference Revisited

Robotics research has now developed to a stage where complete complex systems are robustly possible which coherently integrate perception, action and control on an autonomous mobile platform. The added dimension of more intelligent control and sensing strategies allows autonomous devices progress from the long established Autonomous Guided Vehicles (AGV's) employed in industrial plants to autonomous vacuum cleaners and toys in our home.

So perhaps the lack of successful humanoids is due to the lack of technology, and technology is allowing us to get closer to the goal.

Yet, what is the motivation behind this goal? One argument is that when robots started to wander around the laboratories, our interactions with and perceptions of the robots are continuously influenced (or even contaminated) by our interpretations of them as a form of living entity, whether animal-based or even human. An obvious suggestion for augmenting the social aspect of a robot is to provide even stronger anthropomorphic references such as a face with expressive capabilities to provide visual cues, to embedded speech mechanisms. But where does the designer stop without becoming trapped by the inimitable task of managing expectation on a very human-like robot (see [2])? Anthropomorphism is only useful if it does not complicate people's expectations.

Perhaps then it is not about the humanoid form per se but rather creating machines that offer us a degree of familiarity, particularly in a social context. Familiarity allows us to link to other sentient intelligent beings, whether human, or in the form of a pet such as a dog. Sony Aibo's lack of success as a long-term robotic pet can be attributed to early technology, relatively fragile nature, or more importantly, its too close approximation of a dog (and not completely following through this approximation or illusion). Too close an approximation results in expectations of how it should behave that are extremely difficult to satisfy.

Even examples such as the extremely successful Tamagotchi, a virtual reality pet on an LCD screen developed by Bandai in 1996, makes us think twice about whether the humanoid or animal form should be the frame of reference. The Tamagotchi and its many derivatives are arguably much more successful than the Aibo and yet physically look nothing like a "real" pet.

Perhaps the hypothesis of the pure humanoid being the ultimate frame of reference is too restrictive. In reviewing the "reasons" in viewing the humanoid as the canon for designing human machine interaction, and understanding the balance of the illusion, we see that something more fundamental than the humanoid form surfaces as design guidelines. These guidelines define a core set of functions or characteristics that either meet our expectations or easily bootstrap our interactions with robots. These core features, subsume the human as the ultimate frame of reference in robotics and include:

- *Control:* the ability to influence the robot, or influence our environment through it.

- *Predictability:* but not necessarily overly simplistic and thus too predictable. At the same time it should not be unpredictable or the "bond" we have with the robot can become difficult to maintain.
- *Dependency:* plays on our needs, whether utilitarian (e.g. assembly line), or our satisfaction needs and emotional attachment (e.g. Tamagotchi)

The success of the Tamagotchi and its many derivatives is based on our associations with dependency (the needs the pets have that we will fulfill) and the attraction of perceived unpredictability (not knowing when the pet will be hungry, sleepy, or in a playful mood) yet reliability (if we played with it, it will be happy). An artificial system like the Tamagotchi is designed to constantly vie for our attention through some "feeding" or "loving" mechanisms. Pressure is placed on the person playing with it to provide for its needs in order that it will grow and finally become an "adult", ultimately with its "secret character" appearing if it has been "raised" perfectly. They are designed to fulfill a sense of satisfaction and achievement. Our interactions with the device develop through this artificial notion of dependency and social action and reaction.

When a robot is a tool, its role and function is clear. We control it to perform some behaviour(s), and it is judged according to its ability and reliability (predictability) to succeed in defined tasks (needs). Here, the purist perspective of the human form, with all its complexity, is of little use [3]. It is no more a tool than a hammer, just more complicated.

Similarly, the integration of the robot into a social context, even without a necessarily defined task to be achieved, places an emphasis on reliability (based on social conventions or social predictability) to succeed in establishing a relationship (needs). Here a balance between the robot's function and form becomes crucial [2]. The success of our relationship depends on our expectations, which depends on our assessment of its capabilities, which in turn is directly related to its form and behaviors.

5 Conclusions

With the world robot population surpassing the one million mark and the development of more robust technologies facilitating autonomous devices in our offices and home, the era of the robot has begun. Key to their success is their economic advantage and efficiency. If they can do a better job, quicker and more reliably, then they will replace an existing technology. This paper has, on the one hand, highlighted that so far useful robots have little to do with the human form or function. On the other, aspects of anthropomorphic function and form intuitively provide mechanisms that can facilitate a robot's integration into our social space. However, as we have argued, achieving a balanced design of form and function can be more successful than the literal anthropomorphic form alone. An abstraction away from the human allows a more over-reaching view of what the ultimate references for the future robot should be. The three tenets of control, predictability and dependency subsume the humanoid and other biological inspired frames of reference, and facilitate imaginative solutions to the robots of the future.

References

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