My Robotic Doppelgänger – A Critical Look at the Uncanny Valley

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Abstract— The Uncanny Valley hypothesis has been widely used in the areas of computer graphics and Human-Robot Interaction to motivate research and to explain the negative impressions that participants report after exposure to highly realistic characters or robots. Despite its frequent use, empirical proof for the hypothesis remains scarce. This study empirically tested two predictions of the hypothesis: a) highly realistic robots are liked less than real humans and b) the highly realistic robot's movement decreases its likeability. The results do not support these hypotheses and hence expose a considerable weakness in the Uncanny Valley hypothesis. Anthropomorphism and likeability may be multi-dimensional constructs that cannot be projected into a two-dimensional space. We speculate that the hypothesis' popularity may stem from the explanatory escape route it offers to the developers of characters and robots. In any case, the Uncanny Valley hypothesis should no longer be used to hold back the development of highly realistic androids.

I. INTRODUCTION

THE Uncanny Valley hypothesis was proposed originally by Masahiro Mori [1] and was discussed recently at the Humanoids-2005 Workshop [2]. It hypothesizes that the more human-like robots become in appearance and motion, the more positive the humans' emotional reactions toward them become. This trend continues until a certain point is reached, beyond which the emotional response quickly becomes repulsion. As the appearance and motion become indistinguishable from humans, the emotional reactions also become similar to those toward real humans. When the emotional reaction is plotted against the robot's level of anthropomorphism, a negative valley becomes visible (Figure 1), and this is commonly referred to as the Uncanny Valley. Moreover, movement of the robot amplifies the emotional response in comparison to static robots.

With the arrival of highly realistic androids and computer-generated movies, such as "Final Fantasy" and "The Polar Express" or "Beowulf", the topic has grabbed much public attention. The computer animation company Pixar developed a clever strategy by focusing on non-human characters in its initial movie offerings, e.g. toys in "Toy Story" and insects in "It's a Bug's Life". In contrast, the annual "Miss Digital

World" beauty competition [3, 4] has failed to attract the same level of interest.

The Uncanny Valley has been a hot topic in the research fields of computer graphics (CG) and human-robot interaction (HRI). The ACM Digital library lists 36 entries for an exact search for the phrase "uncanny valley" and Google Scholar lists an amazing 364 entries as of August 15th, 2008. We will review a few papers to provide a short overview of the current research.

Even though Mori's hypothesis was proposed in the framework of robotics, it appears to have been discussed in the field of CG before it became a topic in HRI. The development of computer software and hardware allowed the creation of increasingly realistic renderings of humans before highly realistic androids became available. In the field of CG, Mori's hypothesis is often used to explain why artificial characters are perceived as being eerie [5]. Even Gergle, Rosé & Kraut [6] used the Uncanny Valley hypothesis to explain their results during the presentation of their award-winning paper. The CG community has also specifically investigated the Uncanny Valley [7] and proposed solutions to overcome the Valley [8, 9]. A considerable number of studies in this area have been published, which led to the need for a first review article [10].

But also in the field of HRI, the hypothesis has been used to explain results [11, 12] and to motivate research [13-16]. In addition, Mori's hypothesis is often used as an engineering challenge [17-20]. The first research projects in HRI were conducted to investigate the hypothesis empirically, including studies on the participants' gaze [21, 22], androids as telecommunication devices [23], the perception of morphed robot pictures [24, 25], a sample of robot pictures [26], and the relationship of the hypothesis to the fear of death [27]. A basic limitation that these studies share is that they either focus on a single robot or use pictures and videos instead of real robots. Most research labs, including our own, simply cannot afford multiple sophisticated robots to perform comparative studies.

Mori's hypothesis has also treaded on theoretical grounds [28-30], and even legal considerations have been discussed [31]. These discussions also resulted in proposals of alternative views on the uncanny phenomena [32-34].

This short survey demonstrates that Mori's hypothesis has been widely used to motivate research & development in the fields of CG and HRI. It has also been used to explain the phenomenon of users perceiving highly realistic characters and robots as disturbing. However, the amount of empirical