SeneLudens Robot

Abstract

antÉ, the Institute for the Study of Anticipatory Systems seeks funding for *SeneLudens Robot, a Pilot Project of playful robot agents for the aging* (Project PLAY). The robots to be built will fuse art, game design, cutting edge artificial intelligence, and social robotic hardware, in order to deliver therapeutic games to the aging and elderly. The umbrella project Seneludens© is dedicated to discovering a new category of engaging artifacts—proactive behavior therapy to maintain anticipatory characteristics and thus slow down the aging process and the associated symptoms. The robots and the games associated with them are intended to provide emotional and cognitive stimulation in order to ameliorate age-related cognitive decline, and to maintain the individual's anticipatory characteristics. To accomplish this goal, the Institute will collaborate with Human Emulation Robotics LLC (HER), and with the Institute for Interactive Arts and Engineering (IIAE), thus combining antÉ's expertise in anticipation and IIAE's expertise in game design and interactive arts with HER's acclaimed human-like robotics technology. Input will be sought from cognitive science and brain research, as well as from practicing physicians. antÉ seeks $200,000.00, with matching funds supplied by HER, to finance the design and production of custom-sculpted robot hardware and the development of intelligent language software and animation. Included in this amount are the funds (ca. $150,000) required to perform formal human subject testing using the robots, as well as testing the adequacy of the robot for various individuals. The project deliverables will be an engaging robot biped with an expressive face; socially interactive software, including games; and human subject testing with the robot. Also pursued is validation of the multi-year interdisciplinary project *Seneludens* through a Pilot Project meant to confirm the project's relevance. The SeneLudens Robot will further acknowledge the University of Texas at Dallas (UTD) as a global leader in the areas of affective computing and social robotics, as well as in anticipation systems.

Proposal Narrative

Opportunity

antÉ seeks to combine its research in anticipatory systems, including anticipation as a dimension of game design for the aging and elderly, with HER's cutting-edge social robotics technology.

Presently, the aging and elderly suffer from the effects of social isolation and age-related cognitive decline and social isolation. But studies show that verbal interaction and cognitive stimulation can slow cognitive decline. Currently, few technologies exist to provide cognitive stimulation to the aging population. The proposed social robot system, part of the comprehensive *Seneludens* project, is meant to address this situation. Cognitive scientists, brain researchers, and medical specialists from the pertinent fields will join the effort. A major research effort in computer science (in particular human-computer interaction), artificial intelligence, and anticipatory computation will also be required. Characteristics corresponding to the individual profile of each person will be established using AI methodology (cf. K. Truemper). Extraction of logic relationships will allow us to identify specific interactions (which games correspond to the profile of an individual). We will also see how the games affect anticipation in the aging. The Pilot Project described herein is a first attempt to translate documented requirements concerning the deterioration of anticipatory characteristics of the aging into specs for new technological developments.

The number of the aging and elderly in the United States is rising as Americans live longer. Americans aged 65 and older reached 35 million in 2000, compared to 3.1 million in 1900. Yet the ratio of the elderly to total populace, jumped from 1/25 to 1/8 for these same years [U.S. Census, 2002]. This trend continues to intensify as the baby-boom generation ages. The elderly rate of growth is 75 percent greater than that of the rest of the population. This inequity promises to create levels of demand for human attention that will be extremely difficult to meet. Already, social isolation takes a devastating toll on the elderly [Cacioppo and Hawkley, 2003]. As life expectancy and the aging population increase, so will the number of seniors who live in social isolation.

Age-related cognitive decline affects numerous aspects of a person's health and quality of life [Bosworth & Schaie, 1997]. Cacioppo's and Hawkley's study [Cacioppo and Hawkley, 2003] strongly correlates social isolation with cognitive decline among the elderly; it goes on to find that the related health and cost effects are pointedly devastating. On the other hand, many studies indicate that cognitive stimulation (including games, memory tasks, and conversation) can slow age-related cognitive decline [Wang et al, 2002; Wilson et al, 2003; Verghese et al, 2003], alleviate depression and may improve self-esteem [Lupien et al, 1997]. As the aging population in the USA grows—from 35 million in 2000 to 70 million in 2030 [according to the U.S. census, 2000]—the need for creative solutions that provide cognitive stimulation and conversational companionship will become more urgent. This need will be exacerbated by the financial crisis facing eldercare [US News, and Greenspan, 2004], which will render the expense of hired human companionship all the less tenable. Lower-cost automated solutions are necessary.

The core robot technology developed in the framework of the Pilot Project would represent significant innovation, realizing numerous projects that once upon a time were merely dreams or science fiction. This project will, for the first time, bring together

a. the most expressive robot hardware available today,

b. advanced natural language AI and machine vision technology, and

c. high quality bipedal locomotion hardware

in a useful application for eldercare. The SeneLudens robot with a human face will illustrate other useful applications of the technology—as a public spokesperson, a platform for cognitive science and AI development, a work of theater, and a work of art. This technology will also attract international scientific and public (including media) attention to UTD, which in turn can translate into prestige and opportunities for research funding, necessary for propelling UTD's long-term growth objectives. antÉ considers the opportunity of working with HER—where David Hanson, a Ph.D. candidate at the University is the major player—as a good chance for stimulating student creativity and start-up dynamics.

It bears repeating that funding of the Pilot Project will enable us to seize opportunities for proactive therapies for the aging, individualization procedures, robotics innovation, university development, and public exposure. And it will provide a research infrastructure that will situate the University of Texas at Dallas on the global forefront of anticipation studies, affective computing, and social robotics.

Scope

The funds will be used in several ways that interoperate in order to create a SeneLudens Robot game system.

The engaging human-face PLAY robot has to be simple to use: A Seneludens Robot will start up with a hug or voice command and go to sleep when unused (so that even those affected by memory loss will be able to use them). The endearing, expressive faces and speech interactivity will render the robots intuitive for operation. Base functionality will include face-tracking eye contact, automatic speech recognition, and speech interactivity. In addition to these basic functions, the proposed research will develop games for the robot. Some of these games may be language games. Others may involve physical and tactile interaction. Music and singing will play an important role, too. Additionally, as a conversational companion, the robots may deliver news, e-mail messages, and just talk with or read to the person. (A scanner and a text-to-voice facility will support the "May I read to you?" function.) The robot may optionally contain a built-in screen display to deliver images, text, and video (such as films or instructive material—the "How-to" interactive type). It could also accept a keyboard for advanced operations. The robot will communicate wirelessly with a host PC running most of the software and providing Web connections. In some cases, a professional monitoring service can be considered.

In addition to use as a platform for cognitive games and daily companionship for the aging, the innovations described in this proposal can serve as a platform for general purpose AI development, cognitive science, education (even children's games), and developing future eldercare software. The proposed hardware and software systems will be designed with graphical authoring tools to enable commercial developers and researchers to easily author new hardware designs and new software to run on the robot.

Deliverables

1. The SeneLudens Robot, a cute walking biped with an expressive robotic face.

2. The AI, animation, and language software, composed into elder-games.
3. Procedures for individualization.
4. Broadcast quality documentation.
5. Human subject testing with the robot
6. Procedure for evaluation of the individualized solution.

Funding requirements and utilization

1. The funds we want to raise for this Pilot Project will be used to develop robotic hardware. The robot's face will be sculpted by hand and laser scanned. Digital models of the robot's mechanical systems will be executed in CAD solid models and rapidly prototyped. Tooling will be made for casting the skull and skin. The skin will be cast from F'rubber, HER's proprietary polymer that provides much more realistic expression than animatronics materials while requiring only 1/20th the force [Hanson and White, 2004, United States Provisional Patent Application Serial No. 60/477310]. Consequently, the expression of the robot's face will consume very little energy and will be extremely lightweight. The face will be 2.5" tall; the neck will be .5" long; and the body alone will stand 12" in height. The mechanical systems and head will be assembled and fitted with actuators and electronics. The robot's eyes will be fitted with cameras. Two prototypes will be rendered during phase I, iteratively refining the aesthetics and technology. CAD-supported designs will enable quick adaptation, which facilitates iterative improvements.

By making anthropomorphic facial expressions possible, the SeneLudens Robot will easily divulge its communicative function and thus will invite those playing with it to "address" it, i.e., to talk to it. In order to achieve this, the robot's aesthetic identity, as part of the individualized identity, is important: It should be endearing, and a bit humorous, even provocative, in order to diffuse tension and apprehension. Since our focus is on aging persons, it may be sensible to give the robot a childlike identity, to make the device more immediately acceptable (what the notion of "adorable" expresses). Moreover, the robot will play the role of a robot, not of a human-substitute. The following aspects are very important:

a. Honesty, that is, reveal limitations with sense of "complicity," in order to make the individuals interacting with the robot accept (forgive) the robot's weaknesses and inabilities
b. Not to promise more than what can be delivered. It should not come to the moment when the user is so disappointed that the robot loses its attraction as a "play with me" contraption. When expectations wear off easily, the goal pursued can no longer be achieved.

In order to address such risks, the robot will communicate wirelessly (802.11g) with a local host PC. This allows for refreshment cycles, for a sense of continuous adaptation. Limited computing may also be embedded on the robot. On-board motor control functions will be handled by 16XX series PIC microcontrollers, which are highly effective at multiple motor control. The robot's body will be a "Robovie-M", a $4500, off-the-shelf solution that is very appealing in motion and gesture, and is quite agile (see: http://www.vstone.co.jp/e/rt01e.htm). This robot can walk,

lie down and stand back up, turn a handstand, and dance. Although these advanced functions may be utilized only partially during the scope of the funded activity, they represent room for expanded functionality in later versions. The face hardware will be engineered to mount on existing mount-points on the neck of the Robovie-M hardware. The two will communicate over the Phillips I2C serial protocol so that the programmed movements of the Robovie M will be called by our robot's control system, as appropriate for the entertainment, games, and other interactivity and functions designed during the scope of Phase 1 activity.

2. Second, the funds will apply to software the development, including language, animation, and game design for the robot. In addition, the profile identification expert system will have to be funded. By month 3 of the Pilot Project, we will complete the software design for an early simple game involving cognitive stimulation. Such games may consist of word-games, jokes, or verbal conversation ("How are you doing?" or "A penny for your thoughts" or "Do you want to sing along with me now?). For this game, the robot may additionally engage a person by dancing, performing various tricks, or even hugging the person. In one form of game, the robot may show joy when petted and actively seek such affection.

The games will build on a foundation of AI software systems and authoring tools that to date have largely been prototyped, and are largely composed of off-the-shelf components. The proposed project will continuously advance and refine these systems. For intelligent response to faces and other visual stimuli, we will use Nevenvision's Axiom FFT to see facial expressions, and the Intel Open CV to perceive gestures and general motion will be utilized. For speech recognition capabilities, we will use Sensory's Fluent and the open source Sphinx. We may also use Dragon Naturally Speaking (NS), by making games out of speech training sessions. Once trained, Dragon NS is much more accurate than Sphinx or Fluent. The robot's voice will be the Elan Babs TTS. (In the future, as individualization requires, we might look for alternatives.) The lips will be synchronized via visemes—the visual correspondents to phonemes. These speech and vision systems will be used in tandem (a task known as "sensor fusion") using a software framework adapted from the MIT YARP framework.

To author robot animation, we will utilize Maya via a software plug-in that we have developed. This allows for the creation or refinement of robot animation using Maya's powerful animation tools. Additionally, the UTD Motion Capture (MoCa) Lab, a joint lab of the Computer Science Department and IIAE, with the participation of antÉ, may be used to build a library of animations. To facilitate Maya animation, authoring, and AI software design, a screen-based agent with the robot's likeness will be developed. All the data processing will take place in the antÉ Lab.

By month 5, we will implement the first version of an elder-game, which will run on the face-body hardware. We will then engage in trial runs, obtaining informal feedback from project team members. In months 6 through 9, we will produce iterative improvements of the software systems and hardware systems, while seeking feedback from elder-care professionals. During months 9 through 12, we will assess our work, and plan next-stage robot designs and design improvements. The formal human subject tests with the robots will be planned in detail during this time, to start at month 15.

Broader Impact

The majority of work done will be more generally applicable beyond this SeneLudens project. The hardware designs can be adapted for use in numerous facial identities, and the conversational software is applicable to social robots in general. By developing the software in a highly modular and extensible framework, we lay the foundation for future social robotics. Likewise, the mixed modal sensor fusion will be strongly applicable for use in social robots and agents in general. These systems form the blank slate for further game designs, for eldercare applications and otherwise.

Residing at UTD following project development, the robot can serve indefinitely as a platform for further AI development. Also, the robot can serve as an emissary for the broad *Seneludens* project, and even for the University of Texas at Dallas, representing UTD in the public eye.

As an artwork—one of the first serious works in intelligent robotic figurative sculpture—the results could gain attention in the critical art community.

The research and technology development associated with this investment will enhance UTD's reputation. By providing UTD graduate students with the access to cutting-edge robotic hardware resources, the project will contribute to the pedagogical development and professional training of the next generation of scientists, who will benefit from the momentum of innovative research that the Seneludens project will trigger.

Observation: The academic and media attention associated with this Pilot Project as part of antÉ's *Seneludens* project can improve the recognition (branding) of the institute and increase the odds of securing additional resources for the project and for the University.

Team

Mihai Nadin, Ph.D., (Principal Investigator) Ashbel Smith Professor in Humanities, Engineering, and Computer Science, University of Texas at Dallas. Nadin has delved into the creative aspects of digital technology since he received his degree in electronics, electrical engineering, and computer science. He was a pioneer in computer graphics and human-computer interface. Since his arrival in the USA, he developed innovative courses in computer applications and consulted for higher education institutions in the USA, Europe, and Middle East. He founded the world's first Computational Design Program (University of Wuppertal, Germany). Since 1985, he has researched anticipation (i.e., anticipatory systems in the living) and is currently working in the investigation and application of anticipatory computing. For more information (including publications), see:

http://www.nadin.name

http://en.wikipedia.org/wiki/Mihai_Nadin

David Hanson is a doctoral student at the University of Texas at Dallas and CEO of Human Emulation Robotics LLC. He creates realistic, humanlike social robots that use artificial intelligence to affect eye-contact with people, make extremely

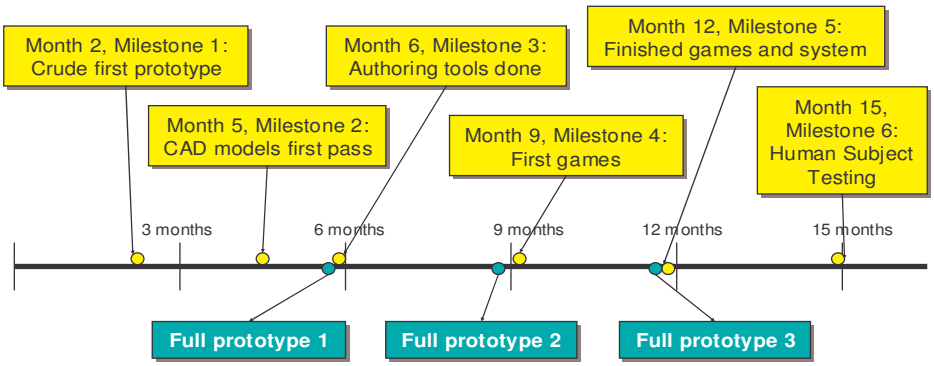
lifelike expressions, and hold spoken, natural-sounding conversations with people. His robots have been featured on CNN, Discovery Channel, in NY Times, WIRED (July 2004), Science, IEEE Spectrum, AI Magazine, and Popular Science (September 2003) among others. His polymer innovations enable robots to make much more realistic expressions than "animatronics". When combined with leading AI and machine perception technologies, these robots offer unprecedented opportunities for expressive portraiture. See:
http://ndeaa.jpl.nasa.gov/nasa-nde/biomimetics/Biomimetic-robot-Hanson.mov
http://androidworld.com/HansonHead.wmv
http://www.cnn.com/2004/TECH/02/02/social.robots.ap/
http://www.csindy.com/csindy/2003-12-11/cover.html
http://www.**science**mag.org/cgi/content/summary/299/5611/1311a
http://www.nytimes.com/2004/03/04/garden/04TEDD.html
http://www.spectrum.ieee.org/WEBONLY/publicfeature/jun04/0604art.html

Property

The robot and the software will become shared property of the University of Texas at Dallas and HER, per the terms of signed Joint Property Agreement and the associated Project Plan. We intend to make most of the resulting innovations widely available for non-commercial and development uses. The intellectual property associated with the Project Plan shall remain available to both parties mentioned above for non-commercial and development uses.

Timeline

Project milestones



Prototype Iterations

Budget

1. Prototyping expenses: materials, supplies, components

1.1	Sculpture		300.00
1.2	Tooling		500.00
1.3	Skin		200.00
1.4	Scanning/ RP		6,000.00
1.5	Robot face materials		1,500.00
1.6	Robomovie-M		4,500.00
1.7	Mechanicals		2,000.00
1.8	Electronics		1,000.00
1.9	Cameras		300.00
1.10	Fasteners, bushings, skulls		250.00
1.11	Skin supplies, shop supplies		500.00
1.12	Eyes		50.00
1.13	Aesthetics		400.00
Subtotal			$17,500.00

2. Hardware Labor

2.1	Sculpture	(50 hrs x $40 per hr)	2,000.00
2.2	Tooling	(25 hrs x $40 per hr)	1,000.00
2.3	Skin	(40 hrs x $40 per hr)	1,600.00
2.4	Mechanicals	(200 hrs x $40 per hr)	8,000.00
2.5	Electronics	(25 hrs x $40 per hr)	1,000.00
Subtotal			$13,600.00

3. Animation Labor

3.1	Motion capture, MoCa clean-up	(80 hrs x $40 per hr) labor	3,200.00
3.2	Human time animating	(40 hrs x $40 per hr) labor	1,600.00
3.3	Facilities usage	(40 hrs x $40 per hr) labor	1,600.00
Subtotal			$6, 400.00

4. Software Labor

4.1	AI language	(160 hrs x $40 per hr) labor	6,400.00
4.2	Refining the machine vision	(80 hrs x $40 per hr) labor	3,200.00
4.3	General software integration	(80 hrs x $40 per hr) labor	3,200.00
4.4	Developing the games	(200 hrs x $25 per hr) labor	11,400.00
Subtotal			$24,200.00

5. Management

5.1	General and artistic	(40 hrs x $40 per hr) labor	1,600.00
5.2	Software	(40 hrs x $25 per hr) labor	1,600.00
Subtotal			$3,200.00

6. Documentation:

6.1	Video/photo documentation	(40 hrs x $40 per hr) labor	1,600.00
6.2	Written documentation	(40 hrs x $40 per hr) labor	1,600.00
6.3	Website	(40 hrs x $40 per hr) labor	1,600.00
Subtotal			$4,800.00

7. Evaluation and various improvements $9,500.00

8. Contingency: $10,000.00

9. Total: $90.000.00

10. Total UTD contribution: $45,000.00

11. Total HER contribution: $40,250.00