FIRST YEAR PROJECT SUMMARY

CHRIS

Cooperative Human Robot Interaction Systems

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Project acronym:		CHRIS	
Project title:		Cooperative Human Robot Interaction Systems	
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1.1 Project Summary and aims

CHRIS is based on the premise that it will be ultimately beneficial to our socio-economic welfare to generate service robots capable of safe co-operative physical interaction with humans. Robots working in shared space with humans will provide significant benefits where robot strength, precision, persistence and indefatigability enhance human performance in certain tasks.

In order for service robots to have the capability required to work with humans in a shared space, certain conditions must be met. Perhaps most importantly, the human must trust that the robot will perform the task appropriately and without harm. To be genuinely useful the robot must be powerful enough to perform the task but inherent in this comes the potential to be dangerous. Consequently the robot must be designed with safety at the heart. CHRIS addresses this directly. CHRIS defines safety through the robot's cooperative interaction with the human, in terms of physically safe (e.g. movements are appropriate and smooth not ballistic or unpredictable), behaviourally safe (e.g. action is largely predictable and understandable by the human), and cognitively safe (e.g. actions are performed following reasoning and planning of the action, evaluation of the possible outcomes and safety implications of the action).

CHRIS will investigate human-human interaction and employ appropriate mechanisms to embed these principles in human-robot interactions. Engineering principles of safe movement and dexterity will be explored on the available robot platforms, and developed with principles of goal negotiation, communication and decisional action planning for appropriate human robot safe interaction.

1.2 Summary description of the project objectives

It is key to the smooth running of the project and achievement of all other objectives to instigate effective management procedures and effective channels of communication. The consortium agreed to such procedures from the outset, ensuring information flow and timely communication across the team.

A vital objective of the project is to understand how human cooperative action occurs both cognitively and physically within a set of chosen scenarios. This will be achieved through human cooperation experiments. Flowing from this, the next objective is to encapsulate these elements, and implement them on robotic platforms through interaction across all the disciplines in the research team. Essential to effective human-robot interaction is safety. To this end a key objective of the project is to assess the safety of human-robot interactions from the aspects of physical safety, behavioural safety, and cognitive understanding, and investigate ways of implementing these as robust features in robot platforms. Having identified these pre-requisites, the research team will develop the engineering principles required to ensure the robot platform is capable of controlled intelligent movement, both gross and dextrous, to perform cooperative tasks with humans safely. Key to the project results having an exploitable economic and social impact, is the rigorous testing of the robustness of the robot platforms pertaining to a changing human-robot interaction environment.

1.3 Work to date

Management and dissemination procedures

Through the Consortium Agreement, effective management and reporting procedures have been instigated to facilitate the process of management and integration across the project. Key objectives of management have been achieved. During the first year of the project we have undertaken four meetings comprising both management and technical sections. Firstly, the creation of the public facing project and an internal project wiki have been created. The project wiki has already proved to be an effective management tool across the consortium for dissemination of information and storage of key documents. Secondly, video-conferencing has been employed by each partner for rapid communication of ideas and results. This functionality augments the communication between the whole project team thus diminishing the impact of geographical separation of the project partners. The added value gained from video-conferencing, in addition to technical meetings, enables smooth integration across the discipline boundaries of psychology, human cognition, computer science and engineering. Finally, risk management has been undertaken and is working well through the employment of a risk register.

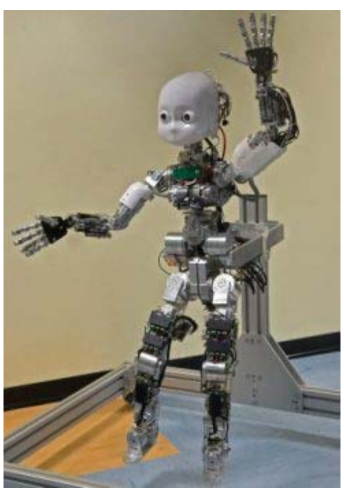
Dissemination of research activity is a key factor in achieving the wider social and economic impacts of the benefits of the research program. To this end the project team have been actively disseminating early results of the project and particularly the aims of the project, through attendance at conferences, workshops, media reporting and publication in journals. This has included broadcasts for the Discovery Channel, the BBC, and technology weblogs. The project website is the permanent public face for the CHRIS project disseminating to the widest possible audience. A regularly updated summary of projects activities is included on this website.

The CHRIS Homepage: http://www.chrisfp7.eu/

Systems Engineering

The overall objective of the Systems Engineering work in the project is to ensure that the work on functional requirements on cooperative activity are properly allocated to the technical tasks, in a coherent functional system. In the pursuit of this objective, during year 1, the project's wiki, which has proven to be indispensable and of constant use in project coordination and technical interaction, has been created. A Scripted Scenario Enactment (SSE), a detailed physical human-robot cooperation scenario using the iCub robot, defining necessary robot behaviour (coordinated with cooperative coordination work) and its allocation to technical tasks has been carried out. This brought the consortium together around a concrete cooperation scenario as a target for our work, which was documented in a Systems Engineering Specification. This involved a concerted activity at the consortium level to specify the global system requirements and corresponding architecture and provides the reference for the system architecture.

Motor Control and Mirroring



iCub

Motor control and mirroring includes the goal to implement explorative behaviors that are safe. The problem of force detection and control has been studied. Techniques have been investigated to disambiguate external forces acting on the robot from the ones originating by the robot's own motion. A new sensor for measuring the tension of tendons has been designed. This will enable force control for the joints that are actuated with tendons (whose size makes the use of traditional strain gauges impractical) to be implemented. A first prototype of this sensor has been built and mounted on a single joint testing rig. A start has been made on investigating techniques for formal software verification. The goal is to guarantee that the most critical parts of the software that control the robot meet certain specifications. Evaluating state of the art tools for formal verification of C code, and the design of novel tools to address the specific challenges of the software controlling the robot at the DSP level has been started. An architecture that integrates safety modules and sensorimotor modules has been designed. Software modules for computing direct and inverse kinematics of arbitrary robotic chains have been implemented. Based on this gaze and arm controllers for the robot iCub have been created. These modules are the building blocks of the software interface to the robot.

Decisional Planning

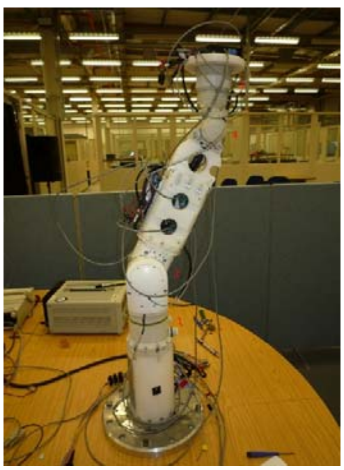
Decisional Planning is vital to safe cooperation in continuous tasks. To achieve this, the objectives include the development of an adaptive planning and control capability that will allow execution autonomy for behaviour at an intermediate level, between sensori-motor control, and high level cooperative interaction. Work in this area so far has essentially concerned a multi-disciplinary investigation of the decisional issues involved in a cooperative human-robot activity. Investigations have also been conducted for the design of a conceptual architecture of the decisional component of a robot companion that acts, learns and interacts with humans. This architecture is aimed to be a framework that provides a basis for a principled way to deal with robot task achievement in presence of humans or in synergy with humans. The building of tools and systems that will be used to implement and demonstrate the envisaged capabilities has been started. An Adaptive Planning Capability Report has been produced. During this period there has been close contact with the cooperative coordination team on human interactive behaviours and associated vocabulary.

Cooperative Coordination

In order to achieve safe Cooperative Coordination between humans and robots, we must understand how this is achieved in humans. During the first year of this project, progress has been made in both the conceptualization and the empirical investigation of the core capacities for coordinated cooperative interaction: Conceptually, key concepts from analytic philosophy for both the study of young children and cognitive robotics has been adopted, resulting in a vocabulary which facilitates communication among behavioural science and robotics. Empirically, we have started to design empirical tests of the core capacities for cooperation in young children, namely behavioural coordination and the representation of joint intentions. Four cooperation tasks have been developed and used in two experiments with children, including the collection, coding, and statistical analyses of the data which will be presented to the scientific community in April 2009. Moreover, the consortium members have worked on adapting these tasks for collaboration scenarios and successfully tested them with two different robotic platforms. In addition, ethical considerations of research with children and naïve participants have been investigated and reported.

HRP2

Safety for Interaction



Torso of BERT2

A requirements analysis for physical and behavioural safety for a robot operating in the CHRIS SSE, was created and agreed on by all partners. In the first 9 months of this period, some work began, ahead of schedule, so as to allow for unforeseen slippage in the project later on. As a result, in the first period, design and construction has already been done on the main torso-trunk of the BERT2 robot platform and a first version of an expressive face, including some low-level physical safety features. Further, a face-tracking system that provides information about both head and eye-gaze direction has been tested; this will be essential equipment for ‘shared attention’ work later in the project. Work has also begun on force-control and ‘zero-G’ operational mode, in which the robot resists gravity but is otherwise passive, so that it can be manipulated directly by a human. All of this work also contributes directly towards physical safety. The VICON Motion Capture system has been tested, using our first wearable garment, for human pose estimation and gesture tracking. This has been integrated with the robot torso-trunk, so that observed human body motion can be used by the robot control infrastructure in real time.

1.4 Significant Results Achieved so far

System Engineering pervades all aspects of this project and runs for the duration of the project. It is vital that these systems are defined at the earliest opportunity to ensure that all partners can follow the design, with the flexibility that comes with advancing research knowledge, and that systems are agile enough to respond and evolve. As such early project milestones and deliverables centred around this work. Milestone 1 was the workshop convened to discuss the functional requirements of a safe cooperative platform with the assistance of the SSE undertaken with the iCub platform. This provided valuable insights in to the capabilities required for a safe cooperative platform.

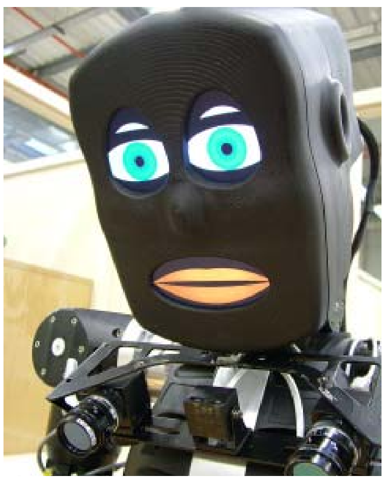
Work in progress on the SSE

An interim Progress Report was delivered to the EC (Deliverable 2) describing the milestones, decisions and project design develop to this point. This detailed the significant progress to systems engineering and the management processes instigated ensuring integration across the project, such as reporting procedures, utilisation of videoconferencing for cross-partner rapid communication, and the wiki as a dissemination tool and digital repository.

Agreements on functional requirements of the robot platform, arising out of the Milestone 1 workshop were formalised in the Systems Engineering Functional Requirements document. The SSE provided the framework of a cooperative coordinated robot platform, providing valuable insight in to the functionalities required through the detailed scripting. The third Meeting of the CHRIS project team led to a further workshop refining the Functional Requirements document (Deliverable 3), in conjunction with a detailed discussion regarding the nature of cooperative coordination. Deliverable 3 was signed off by all partners and delivered to the EC in Month 8.This meeting also led to the development of a common vocabulary for the cross-disciplinary team to employ in discussions about the project, as it became clear that the social-anthropologists were using the same terms but with different meanings from the other teams implementing cognitive principles on the robot platforms. This vocabulary has been posted on the CHRIS wiki for access by all partners.

Milestone 2, decisions on general functional requirements arising from knowledge of capability of the various platforms, were achieved in month 9 following dissemination of the internal deliverables D5.1 and D7.1.

1.5 Expected Final Results and Potential Impact



Prototype of BERT2's expressive face

The CHRIS project focuses directly on the difficult issues concerned with developing the system capabilities which would enable intelligent robots to cooperatively interact with humans in the same physical workspace safely. Intrinsic to this is the ability to have a suitable representation of the goal and the mechanisms to generate motor actions in order to achieve it. Concepts which will be incorporated in the system include control strategies for safe motion, situational awareness, representation of the shared goal/plan of action, and communication both verbal and non-verbal. Currently there is no single system capable of performing all of these activities for safe cooperative action with humans in co-located space, CHRIS aims to achieve this.

Although the design of the project is to ensure research into capabilities rather than to produce a specific platform, potential application areas have already been identified as healthcare, domestic assistant and entertainment. Enabling robots to work in shared spaces with humans will provide significant benefits where robot strength, precision, persistence, indefatigability, or robustness can enhance the human ability to carry out certain tasks. In addition, robots can work in environments where it is unsafe or toxic for humans such as search and rescue in collapsed or smoke filled buildings, or in nuclear decontamination. The potential impact, therefore, of having such capabilities on one robotic platform – not necessarily humanoid in form – for society and the economy is huge. With a projected 80% of the future market share in service robotics, the impact of CHRIS on the development and nature of such platforms could pave the way for Europe to lead in this field.

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