Vetenskapsrådet

Application

2015-03-31

2015-03838 Peters, Christopher NT-14

Information about applicant

Name: Christopher Peters

Doctorial degree: 2004-03-10

Birthdate: 19761218

Academic title: Docent

Gender: Male

Employer: Kungliga Tekniska högskolan

Administrating organisation: Kungliga Tekniska högskolan

Project site: HPCViz, High Performance Computing and Visualization

Information about application

Call name: Forskningsbidrag Stora utlysningen 2015 (Naturvetenskap och teknikvetenskap)

Type of grant: Projektbidrag

Focus: Fri

Subject area:

Project title (english): Walk with me, Galatea: perceptually-based navigation for prosocial multi-agent systems

Project start: 2016-01-01

Project end: 2019-12-31

Review panel applied for: NT-14

Classification code: 20202. Reglerteknik, 10207. Datorseende och robotik (autonoma system)

Keywords: Autonomous systems, Cooperative navigation behaviours, Human perception and interaction, Virtual and physical embodiments

Funds applied for

Year:	2016	2017	2018	2019
Amount:	1,843,000	1,900,000	2,029,000	2,167,000

Participants

Name: Mario Romero

Doctorial degree: 2009-08-01

Birthdate: 19730808

Academic title: Docent

Gender: Male

Employer: Kungliga Tekniska högskolan

Name: Petter Ögren

Doctorial degree: 2003-06-06

Birthdate: 19740912

Academic title: Docent

Gender: Male

Employer: No current employer

Descriptive data

Project info

Project title (Swedish)*

Promenera med mig, Galatea : perceptuellt baserad navigation för prosocialt multiagentsystem

Project title (English)*

Walk with me, Galatea: perceptually-based navigation for prosocial multi-agent systems

Abstract (English)*

Autonomous robots are increasingly required to be able to operate and coexist with humans in complex environments, such as factories, offices and shopping malls. This implies an increasing emphasis on their ability to navigate effectively, safely and efficiently with humans. Current approaches use machine learning techniques with corpora of human navigation behaviours to derive models that are then used to drive robot behaviour. However, these models focus primarily on trajectory data and environment constraints, but do not account for the physical embodiment of robots and the perceptual implications of appearance in the navigation process, which we believe is integral to navigation decisions involving robots. This project will advance the state-of-the-art in human-friendly mobile robot navigation by developing models that better account for robot embodiment, with a focus on gender and personality, in human-robot navigation behaviour. This will be achieved through a series of physical and virtual experiments employing perceptual psychophysics studies in walking scenarios with both real and virtual robots to record quantitative data and probe participant impressions of variations in embodiment related to gender and personality (voice, colour, shape, expressive movement qualities) in a replicable and controlled manner. This dataset is an input into a machine learning process for controlling robot navigation in a manner that also takes the robot's own appearance into account. We anticipate that such models will result in robots that are easier for humans to navigate with and also, are safer and more energy efficient.

Popular scientific description (Swedish)*

Autonoma robotar förväntas i allt högre grad kunna fungera och samexistera med människan i komplexa miljöer, såsom fabriker, kontor, köpcentra och även på slagfält. Således uppstår, en allt viktigare, frågeställning kring hur denna ömsesidiga samexistens säkert och effektivt kan inträffa, med tanke på att mixen verkar representera två extrema och motstående punkter på ett brett spektrum. I den ena änden: olika utvecklade, mycket sociala biologiska varelser. I andra änden: konstgjorda, och
jämförelsevis oflexibla, maskiner utan insikt i den mänskliga tankeverksamheten. Detta projekt avser att utreda en gemensam grund när det gäller navigering för dessa två olika kategorier av självständiga enheter för att göra det möjligt för dem att bättre samexistera. Projektet sammanför framsteg inom robotteknik, maskininlärning, virtuell verklighet och erceptionstekniker för att låta robotar och människor att gå tillsammans, tack vare ömsesidigt accepterade regler, på ett säkrare och effektivare sätt. Detta uppnås genom att förse sorter av robotar med navigeringsbeteenden som närmare matchar människans (dvs. gemensammt kollisionsundvikande) från en analys av riktig data från människor. Detta inkluderar även delar av de upplevda egenskaper hos andra. Dessa egenskaper kan påverka mänskliga navigationsstrategier och förväntas därmed leda till en bättre prediktion av mänskligt beteende hos maskiner, vilket kan innebära mer flytande och effektiva maskin-mänskliga interaktioner när man går.

Project period

Number of project years*

4

Calculated project time*

2016-01-01 - 2019-12-31

Classifications

Select a minimum of one and a maximum of three SCB-codes in order of priority.

Select the SCB-code in three levels and then click the lower plus-button to save your selection.

SCB-codes*

2. Teknik > 202. Elektroteknik och elektronik > 20202. Reglerteknik

1. Naturvetenskap > 102. Data- och informationsvetenskap (Datateknik) > 10207. Datorseende och robotik (autonoma system)

Enter a minimum of three, and up to five, short keywords that describe your project.

Keyword 1*

Autonomous systems

Keyword 2*

Cooperative navigation behaviours

Keyword 3*

Human perception and interaction

Keyword 4

Virtual and physical embodiments

Keyword 5

Research plan

Ethical considerations

Specify any ethical issues that the project (or equivalent) raises, and describe how they will be addressed in your research. Also indicate the specific considerations that might be relevant to your application.

Reporting of ethical considerations*

General:
Research experiments in this project will involve human participants (adults) for data collection and for evaluation of the navigation models. Data will be collected that includes the positions and walking trajectories of participants. Participants will also be asked to fill in questionnaires to rate their impressions of the robots and their overall experience of their interactions with the robots. No physical intervention will take place. All research activities will comply with the current legislation and regulations in Sweden. Approval will be obtained from the relevant ethics committees prior to the start of the activities. The codes of the Swedish Research Council (Vetenskapsrådet) for research experiments will be followed.

Informed Consent:
Participants will be made fully aware of the research aims via participant information sheets before giving informed consent.

Withdrawal:
Participants will be able to withdraw from the research without penalty or judgement at any given time. This will be indicated prior to their participation in the study.

Confidentiality, storage, access to data:
Participants' data will be collected during the project. Personal information will not be stored or combined with this data to ensure confidentiality. Participants will be assigned to an individual identification number. These numbers will be used for self-report and peer nomination. Data stored will not be shared with third parties. All data will be stored in accordance with national and EC legislation. All data collected from these studies will be treated as confidential and stored securely. Images and video recordings of the studies may be shown in scientific papers, conferences and events, but participants will be able to opt-out of this by selecting an option on the consent form.

The project includes handling of personal data

Yes

The project includes animal experiments

No

Account of experiments on humans

Yes

Research plan

Research Plan

WALK WITH ME, GALATEA[1]: PERCEPTUALLY-BASED NAVIGATION FOR PROSOCIAL MULTI-AGENT SYSTEMS

Purpose and aims

This project will develop a novel data-driven navigation control model for robots that accounts for the effects of the robot's own embodiment in human navigation decisions, thus allowing robots to navigate more naturally and efficiently with humans.

Autonomous robots and systems are increasingly required to be capable of operating around humans in complex crowded environments, such as factories, offices and shopping malls. With the advent of autonomous aerial and road vehicles and increasing discussions about the commercial and technical viability of their application to transport and goods delivery in heavily populated areas, more focussed considerations of how autonomous systems and humans co-inhabit and navigate spaces cooperatively is timely. In particular, automating a navigation process that is to take place with humans is a challenging endeavour, since it is fundamentally a social process involving living volitional entities with different capabilities, operating in a different manner to artificial entities.

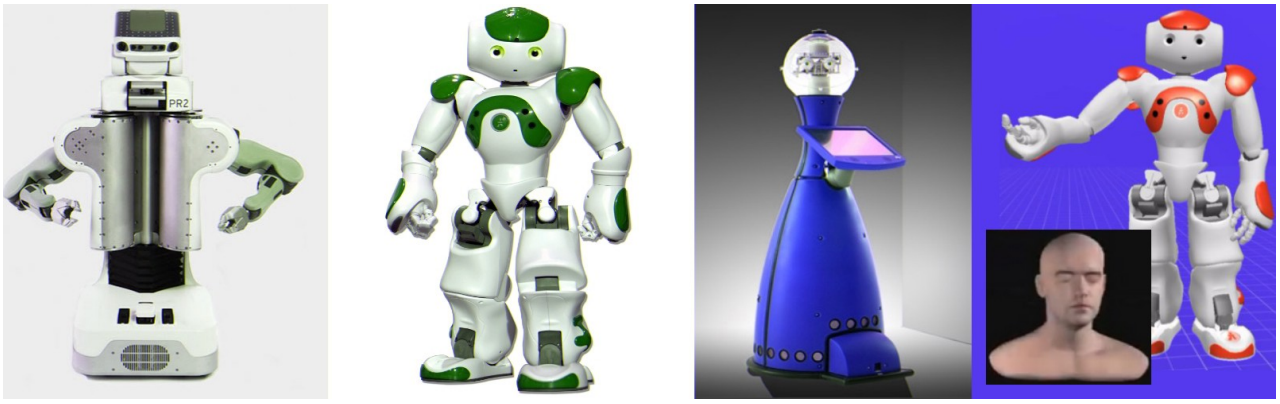

Figure 1. Several physical and virtual embodiments. From left to right, the Willow Garage *PR2*, Aldebaran Robotics *Nao*, Scitos *A5* and a virtual *Nao*. Experiments relating to embodiment and navigation will involve these robots, based at the Center for Autonomous Systems (CAS), KTH. Virtual embodiments are also available that are more humanoid in appearance (right, inset).

Recently, socially compliant approaches have been proposed that use machine learning techniques with corpora of human behaviours to derive navigation models for subsequently driving robot behaviour in a human-like manner. While these models improve on their predecessors, focussing on trajectory data and environment constraints, **they do not account for the impact of the *perceived physical embodiment* (i.e. form, appearance and expressive modalities) of robots on navigation decisions made by humans**. That is, current models based on human-human navigation interactions implicitly embed navigation decisions that are at least partially based on the perceptions, judgements and impressions that human walkers have of each other. **Therefore they cannot account for the effects of varied robot embodiments on those decisions** (see Figure 1 for an example of different embodiments). Yet it seems reasonable to expect the embodiment to have potentially significant effects on how entities are perceived by humans and thus impact their

1 Galatea: in Greek mythology, a name popularly applied to an ivory statue in the shape of a woman, carved by Pygmalion of Cyprus, which came to life. In Western storytelling, a *Galatea figure* is a literary term relating to an artificial person whom someone wishes into life.

subsequent navigation decisions: one may be far more likely to expend the necessary energy to walk around a large and noisy, lumbering hulk of metal, than perhaps a small, quiet, slender and agile looking device. This has a consequential effect on robot navigation modelling that suggests heterogeneity: the navigation system of the large lumbering robot perhaps need not expect to make many trajectory changes to avoid collisions with others, while the slender robot should expect to have to do so frequently and be controlled accordingly.

However, relatively little is known about the exact influence of embodiment types on human navigation decisions, a limiting factor in modelling attempts to date. Therefore, the main scientific objectives of this project are threefold: the **first scientific challenge** relates to establishing mappings between embodiment changes and human impressions that are consequential to their navigation decisions. Even for the specific category of humanoid robots, a large number of potential embodiment alterations are possible and perhaps only a select few may have an impact on the navigation decisions of others. The **second scientific challenge** relates to questions about how to use this mapping data to create navigation models for robots that account for the manner in which they are perceived by humans. Current models only go as far as capturing human navigation behaviour and mapping it onto robots. The **third scientific challenge** relates to how derived navigation models should be evaluated. While it is generally desirable for robots to minimise energy expenditure in navigation situations with humans, this may be achieved in various ways. For example, energy may be conserved at the group level if the output of controllers is more predictable to humans and socially compliant. In order to address these scientific challenges, the project will focus on three specific objectives:

(1) Create a dataset of human impressions related to gender and personality from navigation scenarios involving heterogeneous robot embodiments

(2) Utilise the datasets from objective (1) to create navigation control models that account for appearance during human-robot interactions

(3) Evaluate the outcome of these models in both qualitative and quantitative terms from the perspective of robots, humans and the overall group

In addition to previous research in the area of human-robot navigation, this project will draw upon extensive research conducted in the field of virtual agents, crowd simulation and computer character perception in order to address some of the scientific challenges above. The applicant's research group and collaborators have extensive experience with computational techniques for multi-agent system navigation, with long experience in creating computational models for both physical robots and virtual agents [Peters 2006]. They are also experienced in experimental methods for probing the human perception of artificial behaviour. The starting point of the project is the applicant's work on modelling computational models of navigation [Carretero ert al. 2014][Peters and Ennis, 2009] and conducting evaluation studies of artificial behaviour that include perceptual analyses with human participants [Castellano et al. 2012][Ennis et al. 2011].

If successful, these modelling efforts and subsequent investigations will represent a significant step towards creating *prosocial* control systems that promote cooperative and generally, more social interchanges between humans and robots during navigation situations, with implications for energy consumption, safety and ease of use.

Survey of the field

The methods adopted in this project leverage crossovers in research that involve the use of both physical robot systems and virtual representations (i.e. virtual agents and crowd simulations). Relevant work to this project from the robot navigation domain relates especially to the derivation of data-driven models of human navigation behaviour that are mapped onto robots. In the domain of virtual agents, research of relevance to this project includes well established methods for investigating human impressions of different embodiment types, in addition to augmented

navigation models capable of providing specific impressions about walkers to viewers, for example, in relation to personality traits based on the manipulation of low-level navigation parameters.

Robot navigation with humans

Many approaches that involve modelling and predicting human navigation place the emphasis of collision avoidance and navigation firmly on the robot. More recent approaches [Guzzi et al., 2013] pose more successful strategies by developing control systems accounting mutually for both parties in joint collision avoidance behaviours [Trautman and Krause, 2010] by training machine learning models of human navigation behaviour that are subsequently mapped back onto robots. These trajectories are more human-friendly, since they can be more intuitively predicted and interpreted by humans and enable a better sharing of space between humans and robots. In notable work, [Kuderer et al. 2012; Kretzschmar et al. 2014] used maximum entropy learning based on features that capture aspects of trajectories to determine probability distributions underlying human navigation. They applied this model of human-human navigation behaviour back to the mobile robots in order to allow them to act in a socially compliant manner. However, these solutions are limited since the models do not account for the effects of the physical embodiment of the robot on the navigation decisions of human walkers. It is a natural tendency to anthropomorphise machines based on appearance and we may ascribe them social traits that are influential in the navigation decisions. Therefore, current attempts fall short of properly modelling human behaviour, implying that the derived control systems cannot be expected to operate in a totally human-friendly manner. Nevertheless, these approaches represent a foundation upon which to develop such systems and are a basis for this project.

Virtual characters: embodiment and personality perception

There are many crossovers between the real-time simulation of autonomous virtual individuals and crowds for computer animation purposes [Guy et al. 2010] and similar attempts in robotics [van den Berg et al. 2008]. A number of models in computer animation are based on data-driven approaches, using the data from real walkers to inform simulation efforts [Lee et al. 2007; Lerner et al. 2007; Pettre et al. 2009]. Of special interest are methods attempting to simulate heterogeneous characters in artificial crowds through their navigation behaviours. For example, [Durupinar et al. 2011] used the OCEAN personality model to simulate leadership in crowds through a number of trait descriptive adjectives and conducted a perceptual study with human participants to validate it. In a notable example, [Guy et al. 2011] uses personality trait theory to simulate heterogeneity which is based on a perception user study related low-level navigation parameters such as preferred speed, effective radius and maximum distance of neighbours affecting the agent. Interestingly, the results of this study indicate that low dimensional personality models, such as PEN [Eysenck and Eysenck 1977], offer sufficient dimensions to characterise personality traits in crowd navigation.

The impact of changes in embodiment has also been an active research area in the domain of virtual characters, for example, in relation to the rendering style of characters [McDonnell et al. 2012]. More recent efforts investigate more specific control systems (for example, for gaze control) that are capable of being applied to both physical robots and virtual characters, over multiple embodiments (see [Ruhland et al., 2014] for overview). Generally, these experiments are focussed on social impressions related to the control of characters' faces during close encounters with humans and are have parallels to work in the domain of Human-Robot Interaction related to the perception of physical robots.

So far, little research in this area has considered how changes in embodiment may influence subsequent navigation decisions of humans and no research has attempted to embed such knowledge into a navigation control model.

Project Description

Based on a guiding principle that embodiment matters in navigation scenarios between robots and

humans, this project is a novel mix of mobile robot control, machine learning, perceptual studies and virtual character/crowd simulation research.

Theory

Real-world training data from human-human navigation patterns has been used to develop models capable of making predictions about human navigation behaviour, as demonstrated in [Kuderer et al. 2012]. These models decide each individual's actions based on environment features and the motion of nearby neighbours in the crowd and is based on maximum entropy inverse reinforcement learning [Ziebart et al. 2008], a probabilistic approach related to the principle of maximum entropy.

This approach will be used in the project for defining navigation models that are based on observed demonstrations and can be generalised to new situations.

Trajectories are defined as continuous functions mapping time to position and are represented as a cubic spline defined by many control points. Composite trajectories are vectors of trajectories for a set of agents. A feature is a function that maps a composite trajectory to a real value. The main aim in the approach is to find a probability density function (PDF) that matches the empirical feature values obtained from a dataset. The approach accounts for decision uncertainty through a soft-maximum version of Markov decision processes (MDP) and therefore supports efficient algorithms capable of learning the cost function that best explains previous behaviour and predicts future behaviour. This modelling approach is central to the project, which will use a set of navigation-relevant perceptual data from participants in navigation scenarios as additional feature sets for enabling the model to consider its own embodiment in the navigation control process.

Methodology

Project activities are structured around three main sub-projects: **(1) dataset collection; (2) human-robot navigation modelling; (3) experimental evaluations.**

Although the main studies in the project are envisaged to involve the physical robots shown in Figure 1., this is a limiting factor on the number of participants and scenarios that can be conducted. Therefore the project will also make use of experiments that involve virtual embodiments of robots and virtual reality scenarios as follows.

Virtual reality replicas

The project will adopt the use of high-fidelity virtual reality replica robots and scenarios, developed using pre-existing, off-the-shelf components. These include the Unity[2] 3D computer games engine and inbuilt character animation tools, affordable virtual reality headsets (the Oculus Rift[3]) and virtual reality treadmills (Virtuix Omni[4]). These virtual scenarios will enable participants to walk with virtual robots in scenarios that replicate their physical counterparts and that are controlled by any of the data-driven navigation algorithms developed in the project.

The rationale behind the adoption of virtual replicas related to the first scientific challenge of the project. Virtual embodiments, i.e. replicas of the real robots displayed on screens or in Virtual Reality (VR), allow for controlled modifications to take place that would be costly or infeasible with physical counterparts. This approach is less time-consuming and expensive than setting up physical scenarios and therefore has implications for the amount and quality of data that can be collected and analysed. Furthermore, these technologies allow the appearance and behaviours of robots to be easily altered in ways that would not be possible, or would be prohibitively expensive, with the physical systems. For example, human-scale versions of the smaller physical robots can be easily created, their surface appearance can be made to look like human skin, or wider and taller versions of physical robots can be easily created. Thus, virtual replicas are considered an invaluable aid and are anticipated in the project to enable a greater number of participants to be involved in

2http://www.unity.com

3http://www.oculusvr.com

4http://www.virtuix.com/

perceptual studies during the data collection phase (see Subproject 1) with the consequences that a larger sample group should result in more accurate and robust models.

Subproject 1: Dataset collection
This subproject relates to the data collection phase in the project. It has two main aims: to collect data related to human-human navigation for our specific scenarios in order to build a human-human navigation model for use by robots and to collect data related to the human perception of various robot embodiments.

Dataset collection for human-human navigation model: Data relating to navigation patterns (time, acceleration, velocity, collision avoidance, topological variants) during basic walking scenarios involving groups of individuals will be collected using trajectory tracking capabilities in the Center for Autonomous Systems (CAS) in KTH. These will not involve artificial systems. Video streams will also be captured in order to allow manual annotations to take place by human coders of the gender and perceived personality of the scenario participants [Goldberg, 1992].

Dataset collection for perception of robot embodiments: Data will be collected relating to human impressions of the physical (see Figure 1.) and a variety of modified virtual embodiments derived from virtual replicas. Variations to the three physical embodiments (see Figure 1.) will be made in terms of the gender of the voice [Crowell et al 2009] and expressive movement qualities in a controlled manner to probe corresponding ratings from human participants. Well established questionnaires will be used to query impressions of personality according to the five-factor OCEAN model [Goldberg, 1992], in addition to gender, animacy, anthropomorphism, perceived intelligence and safety [Bartneck et al., 2009]. Since the colour and similar attributes of the physical robots cannot be easily changed, high-fidelity virtual (i.e. computer generated) replicas of the physical robots will be created during this phase in order to be able to collect similar data in relation to colour and other appearance modifications.

Participants will be recruited from the substantial local student population, with whom the applicant has already conducted numerous perceptual experiments using virtual characters.

Subproject 2: Human-robot navigation modelling
This subproject will focus on the development of models of robot navigation based on the datasets from Subproject 1. These models include a basic model derived solely from human-human navigation data, but also variants that related to specific physical embodiment features. These models will be evaluated and compared in Subproject 3.

Development of human-human navigation model: Based on the dataset from human participants in Subproject 1, an initial human-human navigation model (HH1) will be capable of controlling the robots in the manner detailed in [Kuderer et al. 2012] for our specific scenarios and participants. This is one of a number of navigation models that will be used for experimental analysis in Subproject 3.

Feature encoding: The perceived characteristics of robots from Subproject 1 will be analysed in order to establish a set of important features related to embodiment that will become part of the machine learning process during the development of the respective human-robot navigation models. The approach for doing involves a factor analysis based on the results of the perceptual studies and is based on the method adopted by [Guy et al. 2011] for identifying and deriving mapping between specific personality traits and low level navigation parameters. Here, we will extend the concept to also include other aspects of embodiment (including gender, animacy, anthropomorphism, perceived intelligence and safety as described above).

Development of human-robot navigation models: The human-human navigation (HH1) model will be used as a basis for controlling the navigation of robots during a second round of experiments involving human participants and robots. In these experiments, different physical robots will be used and important attributes of the robots will be varied, either using the real-world scenario or virtual reality scenarios. Participants in the study will be asked to navigate with robots in a variety of navigation scenarios while their trajectories are tracked using overhead cameras. The resulting data will be used to define a series of human-robot navigation models (HR1-n) that consider attributes related to the respective embodiments of the robots in the test scenarios.

Subproject 3: Evaluation

This subproject involves a series of evaluation studies between the human-human navigation model (HH1) and the series of human-robot navigation models (HR1-n). Models will be compared, per embodiment, by applying the respectively trained models to matched and mismatched robot embodiment conditions across the navigation scenarios. Quantitative data from human participants relating to the ease and naturalness of navigation will be collected. Quantitative data relating to both robot and human navigation trajectories in the scenarios will also be compared across multiple conditions via a comprehensive suite of evaluation metrics to provide information relating to energy usage and comfort ratios between humans and machines; the similarity of robot navigation behaviour suggested by models across embodiments; and the similarity between navigation behaviour suggested by models and human data. In order to conduct these measures, existing metrics will be utilised. These include metrics from the Steerbench suite [Singh et al. 2009] for benchmarking steering behaviours in terms of collisions, turning, distance and speed, speed-change and acceleration and the entropy-based similarity measure [Guy et al. 2012]. Additionally, we will also conduct user perception studies [Ennis et al. 2011] in order to determine how realistic the artificially generated navigation behaviours look to humans. These will involve both the video streams recorded as part of the datasets and behaviour visualisations that represent various features of the navigation behaviours, such as trajectories over time. This is an important consideration if the navigation behaviours of humans are perceptually-based. In this case, the entropy-based similarity measure [Guy et al. 2012] may also be useful as a quantitative measure as it has been shown to correlate well with the perceived realism of crowds reported by humans.

Due to differences in perception of humans in real and virtual reality environments, the suite of metrics will also be able to compare and establish the validity of the walking patterns in VR scenarios. We also expect this to be a fruitful area of research, since it is possible that only certain aspects (such a low-level navigation parameters) may map well between the real and virtual environment. The evaluation metrics described above are capable of providing an in-depth analysis about this, as it is still an open question in the scientific literature.

Timeline

This project has a lifespan of four years. The key milestones in the projects are:

Year 1: Development of the test-bed scenario and initial dataset collection for human-human navigation model.

Year 2: Feature encoding process ensues. Human-human navigation model (HH1) is developed and tested in some initial scenarios.

Year 3: Development of a series human-robot navigation models (HR1-n).

Year 4: Series of evaluation comparing the different navigation models under varying conditions.

Existing equipment and resources

This project will be able to make use of the equipment and supportive expertise available at the main partner's research centres: the Visualisation Studio and Center for Autonomous Systems (CAS) at KTH. These include many types of software relevant to the technical and experimental fulfilment of the project, notably including a large high-resolution 4K screen capable of rendering

life-size virtual embodiments. In relation to mobile robots, at CAS, there are six full-body *Nao*, a Scitos *A5* and a Willow Garage *PR2* (see Figure 1). The CAS facility also includes the infrastructure available for controlling robot formations based on centralised control and overhead tracking. The main equipment funding sought for the project through VR is specialist virtual reality equipment, specifically, virtual reality headsets, a virtual reality treadmill allowing unrestricted low- to mid-velocity 360 degree locomotion in virtual environments and a graphics-capable desktop machine for rendering high-fidelity virtual characters and environments in real-time..

Furthermore, the machine learning algorithms to be utilised in this work imply a substantial amount of processing time. As a member of the High Performance Computing and Visualisation Department, the PI is well placed to consider high-performance offline implementations of some of the algorithms, for example, utilising the new Cray X40 system *Beskow* at PDC, CSC.

Significance

This project is significant to a variety of endeavours where the prediction and modelling of likely human formation behaviour is important. Application domains include assistive robots in crowded environments and go beyond the context of walking with autonomous artificial entities, to potentially include visual surveillance applications.

The methodology employed in this project is significant since it is capable not only of mapping human navigation behaviours onto models of robot control, but considers a further level of recursion in using these models. That is, the human-human model is used as a first stage and then further developed to include embodiment features specific to the robot. The methodology is also significant to other researchers on the domain of robot navigation, as it involves a perceptual approach from the domain of computer animation and applies it as a set of features in a machine learning approach for robot navigation.

The use of virtual reality technologies, allowing many different virtual embodiments and walk through scenarios to be created in a cost effective manner, is also significant as a way to conduct experiments in a more cost effective manner. This has scientific implications, as lower cost experiments allow more of them to take place and thus larger numbers of trials in order to enable the creation of more substantial and elaborate source corpora for machine learning endeavours.

More generally, at a national and societal level, this project has implications of significance for a host of transport and human well-being issues in future cities. Viable technologies, such as autonomous cars [Wired, 2014; Forbes, 2014], quadruped cargo haulers [Boston Dynamics, 2013] and delivery UAVs [Forbes, 2013], even if still in their infancy, are starting to emerge and imply the potential mass use of autonomous physical systems for the movement of goods, people or services from one location to another.

Preliminary Results

This project is founded on the latest results from the literature for modelling cooperative human-robot navigation [Kretzschmar et al. 2014] and conducting perceptual studies related to the embodied artificial characters [Carretero et al. 2014]. The cross domain interplay between perception and navigation modelling is crucial to the project and is a research area in which the applicant has a substantial research background [Peters and Ennis, 2009][Ennis et al. 2011].

Another novel aspect of the project is the mix between real and physical embodiments. Preliminary work in this area related to gaze control models that can be transferred between embodiments and that account for the nature of the embodiment (for overview, see [Ruhland et al. 2014]). The applicant has conducted research relating both physical robots and virtual agents and crowds, for example, behaviour copying from humans to machine embodiments [Castellano et al. 2012] and strategies for autonomous agents to open interaction through subtle negotiations and [Peters, 2006], both of consequence to this project.

In relation to the creation of cooperative and prosocial artificial systems, the applicant as the PI for KTH in the Horizon 2020 PROSOCIALLEARN, will develop control mechanisms for the

cooperative behaviour of real-time artificial agents. The project modelling efforts also fit in well with a number of projects concerning high-density crowd simulation, rendering and perception supervised by the applicant that are currently in progress at KTH (see Figure 2. left and central images).

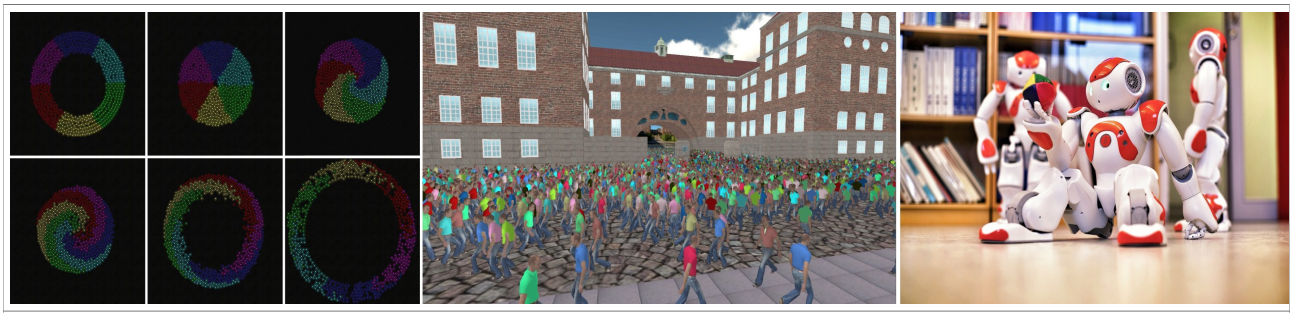

Figure 2. Example of ongoing projects in both HPCViz and CAS of relevance to the project. Particle and continuum-based models of virtual crowds (left) for creating high-density crowd simulations (center) and the CAS infrastructure for mapping group behaviours onto robots (right).

Form of employment
Peters joined the Department of High Performance Computing and Visualisation in January 2013 as a tenured Associate Professor in Computer Graphics and Human Computer Interaction with a 50% research allocation.

National and International Collaboration
Peters has a large network of international collaborators of relevance to this proposal. The applicant maintains a large international network of collaborators, originating both from his academic career experience in Ireland, France and the UK and as a result of involvement in a number of European projects, such as the HUMAINE FP6 NoE (concerning emotion-oriented systems) and Metropolis *Supercrowds* (multisensory crowd simulation in urban environments). More recently, Peters was become Principal Investigator for KTH on a new Horizon 2020 project concerning prosocial systems, with a focus on developing computational models that enable artificial agents to engage in cooperative behaviours with humans. This network offers a rich source of potential research, data gathering and dissemination collaborations both within academia and industry.

Other grants
This proposal has not been submitted to any other funding body. The applicant (Christopher Peters, KTH) is the Principal Investigator for KTH in the €4.197m EC Horizon 2020 Innovation Action PROSOCIALLEARN. This European consortium of industry, universities and educational institutions will create prosocial game technologies. The role of KTH, (funding: €240,383) focuses on the creation of computational models of prosociality for controlling the behaviour of real-time artificial systems. If applicant has ensured that, should the current project be accepted, adequate research time is available to properly conduct both projects.

References

Peters, C. A perceptually-based theory of mind model for agent interaction initiation, International Journal of Humanoid Robotics (IJHR), Special Issue: Achieving Human-Like Qualities in Interactive Virtual and Physical Humanoids, 3(3), pp. 321-340, World Scientific Publishing, 2006

Carretero, M.R., **Peters, C.**, Qureshi, A. Modelling emotional behaviour in virtual crowds through expressive body movements and emotion contagion. SIGRAD, pp. 95-98, 2014

Peters, C. and Ennis, C. Modeling Groups of Plausible Virtual Pedestrians. IEEE Computer Graphics and Applications, 29(4), pp. 54-63., IEEE Computer Graphics and Applications 29 (4), 54-

63, 2009

Castellano, G., Mancini, M., **Peters, C.**, and McOwan, P. W., Expressive copying behavior for socially interacting machines: A perceptual analysis, IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, 42(3), pp. 776-783, May 2012

Ennis, C., **Peters, C.**, and O'Sullivan, C. Perceptual effects of scene context and viewpoint for virtual pedestrian crowds. ACM Transactions on Applied Perception, 8(2): 10, 2011

Guzzi, J.; Giusti, A.; Gambardella, L.M.; Theraulaz, G.; Di Caro, G.A., Human-friendly robot navigation in dynamic environments, Robotics and Automation (ICRA), 2013 IEEE International Conference on, vol., no., pp.423-430, 6-10 May, 2013

Trautman, P.; Krause, A., Unfreezing the robot: Navigation in dense, interacting crowds, Intelligent Robots and Systems (IROS), 2010 IEEE/RSJ International Conference on , vol., no., pp.797-803, 18-22 Oct. 2010

Kuderer, M., Kretzschmar, H., Sprunk, C., Burgard, W. Feature-Based Prediction of Trajectories for Socially Compliant Navigation. Proceedings of Robotics: Science and Systems, July 2012

Kretzschmar, H., Kuderer, M. and Wolfram, B. Learning to Predict Trajectories of Cooperatively Navigating Agents. In Proc. of the IEEE International Conference on Robotics and Automation (ICRA), Hong Kong, China, 2014

Guy, S.J., Lin, M.C. and Manocha, D. Modeling collision avoidance behavior for virtual humans. In Proceedings of the 9th International Conference on Autonomous Agents and Multiagent Systems: volume 2 - Volume 2 (AAMAS '10), Vol. 2. International Foundation for Autonomous Agents and Multiagent Systems, Richland, SC, 575-582, 2010

van den Berg, J., Lin, M.C., Manocha, D., Reciprocal Velocity Obstacles for Real-Time Multi-Agent Navigation, Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), 2008

Lee, K.H., Choi, M.G., Hong, Q. and Lee, J. 2007. Group behavior from video: a data-driven approach to crowd simulation. In Proceedings of the 2007 ACM SIGGRAPH/Eurographics symposium on Computer animation (SCA '07). Eurographics Association, Aire-la-Ville, Switzerland, Switzerland, 109-118, 2007

Lerner, A., Chrysanthou, Y., Lischinski, D., Crowds by example. Computer Graphics Forum, 26(3), 2007

Pettré, J., Ondřej, J., Olivier, A.-H., Cretual, A., Donikian, S. Experiment-based modeling, simulation and validation of interactions between virtual walkers. In Proceedings of the ACM SIGGRAPH/Eurographics Symposium on Computer Animation (SCA '09), 189-198, 2009

Durupinar, F., Pelechano, N., Allbeck, J.M., Gudukbay, U., Badler, N.I. How the Ocean Personality Model Affects the Perception of Crowds, IEEE Computer Graphics and Applications, vol. 31, no. 3, pp. 22-31, May/June, 2011

Guy, S.J., Kim, S., Lin, M.C., Manocha, D. Simulating heterogeneous crowd behaviors using personality trait theory. In *Proceedings of the 2011 ACM SIGGRAPH/Eurographics Symposium on Computer Animation* (SCA '11), Stephen N. Spencer (Ed.). ACM, New York, NY, USA, 43-52, 2011

Eysenck S.B., Eysenck H.J., The place of impulsiveness in a dimensional system of personality description. Br J Soc Clin Psychol.; 16(1):57-68, February 1977

McDonnell, R., Breidt, M., and Bülthoff, H.H. Render me real?: investigating the effect of render style on the perception of animated virtual humans. ACM Trans. Graph. 31(4), Article 91, July 2012

Ruhland, K., Andrist, S., Badler, J.B., **Peters, C.**, Badler, N.I., Gleicher, M., Mutlu, B., McDonnell, R. Look me in the eyes: A survey of eye and gaze animation for virtual agents and artificial systems,

State of the Art Report, Eurographics, Strasbourg, France, 2014

Ziebart, B.D., Maas, A., Bagnell, J.A. and Dey, A., Maximum Entropy Inverse Reinforcement Learning, Proceedings of AAAI 2008, July, 2008

Crowell, C.R., Scheutz, M., Schermerhorn, P. and Villano, M. Gendered voice and robot entities: perceptions and reactions of male and female subjects. In Proceedings of the 2009 IEEE/RSJ international conference on Intelligent robots and systems (IROS'09). IEEE Press, Piscataway, NJ, USA, 3735-3741

Bartneck, C., Kulić, D., Croft, E., & Zoghbi, S. Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots. Int J Soc Robot, 1, 1, 71—81, Jan 2009.

Goldberg, L.R., An Alternative 'Description of Personality': The Big-Five Factor Structure, J. Personality and Social Psychology, vol. 59, no. 6, pp. 1216–1229, 1992

Singh, S., Kapadia, M., Faloutsos, P., and Reinman, G. SteerBench: a benchmark suite for evaluating steering behaviors. Comput. Animat. Virtual Worlds 20 (5-6), 533-548, 2009

Guy, S.J., van den Berg, J., Liu, W., Lau, R., Lin, M.C., and Manocha, D. A statistical similarity measure for aggregate crowd dynamics. ACM Trans. Graph. 31(6), Article 190, November 2012

Wired, Article: Volvo Thinks Magnetic Roads Will Guide Tomorrow's Autonomous Cars, http://www.wired.com/2014/03/volvo-magnets-autonomous/

Forbes, Article, Meet Amazon Prime Air, A Delivery-By-Aerial-Drone Project, 2012. Online: http://www.forbes.com/sites/matthickey/2013/12/01/meet-amazon-prime-air-amazons-delivery-by-aerial-drone-project/

Boston Dynamics, Big Dog, 2013 Online: http://www.bostondynamics.com/robot_bigdog.html

Forbes, Article, Self-Driving Cars Will Take Over By 2040, 2013. Online: http://www.forbes.com/sites/eco-nomics/2012/09/25/self-driving-cars-will-take-over-by-2040/

Carretero, M.R., Qureshi, A., **Peters, C**. Evaluating the perception of group emotion from full body movements in the context of virtual crowds, Proceedings of the ACM Symposium on Applied Perception, August 08-09, Vancouver, British Columbia, Canada, 2014

Interdisciplinarity

My application is interdisciplinary

☐

An interdisciplinary research project is defined in this call for proposals as a project that can not be completed without knowledge, methods, terminology, data and researchers from more than one of the Swedish Research Councils subject areas; Medicine and health, Natural and engineering sciences, Humanities and social sciences and Educational sciences. If your research project is interdisciplinary according to this definition, you indicate and explain this here.

Click here for more information

Scientific report

Scientific report/Account for scientific activities of previous project

---

Budget and research resources

Project staff

Describe the staff that will be working in the project and the salary that is applied for in the project budget. Enter the full amount, not in thousands SEK.

Participating researchers that accept an invitation to participate in the application will be displayed automatically under Dedicated time for this project. Note that it will take a few minutes before the information is updated, and that it might be necessary for the project leader to close and reopen the form.

Dedicated time for this project

	Role in the project	Name	Percent of full time
1	Applicant	Christopher Peters	40
2	Participating researcher	Petter Ögren	10
3	Participating researcher	Mario Romero	10
4	PhD Student	Doktorand	100

Salaries including social fees

	Role in the project	Name	Percent of salary	2016	2017	2018	2019	Total
1	Applicant	Christopher Peters	40	352,000	360,000	369,000	379,000	1,460,000
2	Participating researcher	Petter Ögren	10	88,000	91,000	93,000	95,000	367,000
3	Participating researcher	Mario Romero	10	86,000	88,000	90,000	93,000	357,000
4	PhD Student	Doktorand	100	546,000	601,000	661,000	727,000	2,535,000
	Total			1,072,000	1,140,000	1,213,000	1,294,000	4,719,000

Other costs

Describe the other project costs for which you apply from the Swedish Research Council. Enter the full amount, not in thousands SEK.

Premises

	Type of premises	2016	2017	2018	2019	Total
1	Kontor	129,000	138,000	146,000	156,000	569,000
	Total	129,000	138,000	146,000	156,000	569,000

Running Costs

	Running Cost	Description	2016	2017	2018	2019	Total
1	Small equipment	Virtual reality equipment (Oculus Rift, Omni)	25,000				25,000
2	Travel and conferences		15,000	25,000	35,000	35,000	110,000
3	Publication costs	Open access	5,000	5,000	5,000	10,000	25,000
4	Consumables	Graphics and virtual reality capable desktop computer and software licenses	40,000				40,000
	Total		85,000	30,000	40,000	45,000	200,000

Depreciation costs

Depreciation cost	Description	2016	2017	2018	2019

Total project cost

Below you can see a summary of the costs in your budget, which are the costs that you apply for from the Swedish Research Council. Indirect costs are entered separately into the table.

Under Other costs you can enter which costs, aside from the ones you apply for from the Swedish Research Council, that the project includes. Add the full amounts, not in thousands of SEK.

The subtotal plus indirect costs are the total per year that you apply for.

Total budget

Specified costs	2016	2017	2018	2019	Total, applied	Other costs	Total cost
Salaries including social fees	1,072,000	1,140,000	1,213,000	1,294,000	4,719,000		4,719,000
Running costs	85,000	30,000	40,000	45,000	200,000		200,000
Depreciation costs					0		0
Premises	129,000	138,000	146,000	156,000	569,000		569,000
Subtotal	1,286,000	1,308,000	1,399,000	1,495,000	5,488,000	0	5,488,000
Indirect costs	557,000	592,000	630,000	672,000	2,451,000		2,451,000
Total project cost	1,843,000	1,900,000	2,029,000	2,167,000	7,939,000	0	7,939,000

Explanation of the proposed budget

Briefly justify each proposed cost in the stated budget.

Explanation of the proposed budget*

Christopher Peters and Mario Romero are with the Visualisation Studio (VIC Stockholm) in the Department of High Performance Computing and Visualisation (HPCViz) of KTH's School of Computer Science and Communication. Petter Ögren is affiliated with the Center for Autonomous Systems (CAS) and Computer Vision and Active Perception Lab (CVAP) of KTH's School of Computer Science and Communication.

The project is planned to have a four year total duration. The research group will include the main applicant Christopher Peters (working in the project for 40% of his time for four years), a PhD student (100% for four years, supervised by the main applicant and co-investigators). Co-investigator Petter Ögren CAS, KTH (working in the project at 10% for four years) will provide support on the physical robot embodiments and the lab. Co-investigator Mario Romero (working in the project at 10% for four years) will provide support in virtual reality interaction and behaviour visualisations for evaluation.
Björn Thuresson, the director of the Visualization Studio (https://www.kth.se/en/csc/forskning/hpcviz/forskning/2.48237/om-studion-1.346779) has also pledged his support to the project. The studio provides good support for public dissemination activities, including school visits to develop interest in STEM education and industry outreach through the studio's well-developed and extensive collaboration connections.

This project will be able to make use of the equipment and supportive expertise available at the main partner's research centers: the Visualisation Studio and the Center for Autonomous Systems (CAS) at KTH. These include many types of software relevant to the technical and experimental fulfilment of the project, including a large high-resolution 4K screen capable of rendering life-size virtual embodiments, six full-body *Nao*, a Scitos *A5* and a Willow Garage *PR2*.

The main equipment funding sought for the project through VR is specialist virtual reality equipment, specifically, a graphics (GPU) capable desktop computer, *Oculus Rift* virtual reality headsets and an *Omni* virtual reality treadmill allowing unrestricted low- to mid-velocity 360 degree locomotion in virtual environments.

Some of the processing involved in the project is quite intensive. The PI is a member of the High Performance Computing and Visualisation Department, and is therefore well placed to consider the use of high-performance implementations capable, for example, of utilising the new two petaflop Cray X40 system *Beskow* at PDC (https://www.pdc.kth.se/resources/computers/beskow).

Other funding

Describe your other project funding for the project period (applied for or granted) aside from that which you apply for from the Swedish Research Council. Write the whole sum, not thousands of SEK.

Other funding for this project

Funder	Applicant/project leader	Type of grant	Reg no or equiv.	2016	2017	2018	2019

CV

CURRICULUM VITAE
Christopher Peters

Contact address
KTH-CSC School of Computer Science and Communication
10044 Stockholm
Email: chpeters@kth.se
Web: https://www.kth.se/profile/chpeters/

1. Higher education degree
1999: BA (Mod) in Computer Science, First-class Honours, School of Computer Science and Statistics, Trinity College Dublin, Ireland.

2. Doctoral degree
2004: PhD Computer Science, Image Synthesis Group, Trinity College Dublin, Ireland. Title: "Bottom-up Visual Attention for Autonomous Virtual Human Animation", Supervisor: Prof. Carol O' Sullivan (Disney Research/Trinity College Dublin).

3. Postdoctoral positions
2007-2008: Graphics, Vision and Visualisation Group (GV2), Trinity College Dublin, Ireland.
2004-2008: LINC Communication Laboratory, University of Paris VIII, France.
2003-2004: Image Synthesis Group (ISG), Trinity College Dublin, Ireland.

4. Docent level
2014: Docent, Lecture entitled: "Computational Modelling of Human Behaviour: Simulating, Perceiving and Interacting with Embodied Virtual Agents and Crowds", CSC, KTH Royal Institute of Technology, Sweden.

5. Present position
2013-present: Associate Professor in HCI and Computer Graphics, KTH Royal Institute of Technology, Stockholm, Sweden.
2013-present: Visiting research fellow, Serious Games Institute, United Kingdom.

6. Previous positions and periods of appointment
2008-2012: Senior Lecturer, Computer Game Technologies, Coventry University, United Kingdom.
2000-2003: Part-time Lecturer, Computing Faculty, Griffith College Dublin, Ireland.

7. Interruption in research
N/A

8. Supervision
Present: Second supervisor of three PhD students at: KTH Royal Institute of Technology, Sweden; Uppsala University, Sweden; and Birmingham University, United Kingdom.
2000-present: Supervision of numerous Master-level theses in Griffith College, Dublin, Ireland; Coventry University, United Kingdom and KTH Royal Institute of Technology, Sweden.
2010: Co-supervised the PhD of Cathy Ennis, Trinity College Dublin, Ireland.

9. Other relevant information

Notable funding
2015: Principal Investigator for KTH, EC Horizon 2020 Innovation Project, "PROSOCIALLEARN", €4.197M. Consortium of European industry, education and research partners developing prosocial technologies and games supporting educational scenarios with children aged 7-11 in a large network of schools across the United Kingdom, Italy and Greece.
2014: Co-Principal Investigator, KTH CSC CPU pedagogy grant, "An Activity-led Approach to Modelling and Simulation through Interactive Games Technologies", 118 kSEK.

Conference organisation
2015: General chair, SIGRAD (Eurographics) Computer Graphics and Animation Conference. Special focus on computer graphics for computer games technologies and education.

Research awards
2010: Best paper award for "Animating Gaze Shifts for Virtual Characters based on Head Movement Propensity", IEEE International Conference on Games and Virtual Worlds for Serious Applications, Portugal.
2002: Best paper award for "A Memory Model for Autonomous Virtual Humans", Eurographics Ireland Workshop 2002, Media Lab Europe.

Keynote speech
2013: "Computational Modelling of Artificial Behaviour: A Perceptual Approach", VS Games 5th International Conference on Games and Virtual Worlds for Serious Applications, Bournemouth University, United Kingdom.

Selected invited seminars
2012: "Perception of Humanoid Agents and Pedestrian Crowds in Simulated Virtual Environments", School of Electronic, Electrical and Computer Engineering, University of Birmingham, United Kingdom.
2011: "Visual Perception and Directionality for Modelling and Evaluating Artificial Crowd and Agent Behaviour", Fondazione Bruno Kessler (FBK), Trento, Italy 2009: "Synthetic Characters: Behaviour Modelling, Perception and Interaction", University of Sheffield, United Kingdom.
2008: "A Perceptually-Based Theory of Mind Model for Supporting Agent Interaction Behaviours", Invited speaker to "Theory of Mind" (ToM) Analysis of the integrative potential of a cognitive capacity, ZiF Center for Interdisciplinary Research, Bielefeld University, Bielefeld, Germany.

External examining duties
2013: PhD jury member (external 'Rapporteur'), Anis Ur Rahman, "Face Perception in Videos: Contributions to a Visual Saliency Model and its Implementation on GPUs", supervised by Prof. Dominique Houzet and Prof. Denis Pellerin, GIPSA-Lab, Image and Signal Department, University of Grenoble, France.
2012: Invited external academic expert, course approval panel, MSc in Video Game Enterprise and Production, New Technology Institute (NTI), Birmingham City University, United Kingdom.

Duties as editor
2012: Special Issue on Affective Interaction in Natural Environments, ACM Transactions on Interactive Intelligent Systems (G. Castellano, K. Karpouzis, J.C. Martin, L.P. Morency, L. Riek).
2011: Section Editor, section "Emotion in interaction", Emotion-Oriented Systems: The HUMAINE Handbook, Springer, ISBN 978-3-642-15184-2.

Reviewing
Served on numerous programme committees, including Autonomous Agents and Multiagent Systems (AAMAS), IEEE International Conference on Multimedia and Expo (ICME), Computer Animation and Social Agents (CASA) and Intelligent Virtual Agents (IVA).
Participated in reviewing duties for a number of journals and conferences, including Human-Computer Interaction (HCI), IEEE Transactions on Affective Computing, Journal of Autonomous Agents and Multiagent Systems, Virtual Reality, Neural Computing and Applications, IEEE Systems, Man and Cybernetics, IEEE Computer Graphics and Applications, Elsevier Computers and Graphics, IEEE Transactions on Visualization and Computer Graphics, Pacific Graphics, ACM Siggraph (technical track) and Eurographics (technical and education tracks).

Publications
Over 80 peer-reviewed, technical publications in scientific journals, conferences and symposia, receiving over 1000 citations (Google Scholar profile 'Christopher Edward Peters', 20/03/2015).

Curriculum Vitae

Personal Data

Name:	Petter Ögren	**Phone:**	+46 (0)8 790 6664
Born:	Stockholm, Sweden, September 1974	**Fax:**	+46 (0)8 723 0302
Affiliation:	CVAP, CSC, KTH	**E-mail:**	petter@kth.se
	SE-100 44 Stockholm, Sweden	**URL:**	www.csc.kth.se/~ petter

Petter Ögren was born in Stockholm, Sweden, in 1974. He received the M.S. degree in engineering physics and the Ph.D. degree in applied mathematics from the Royal Institute of Technology (KTH), Stockholm, Sweden, in 1998 and 2003, respectively. In the fall of 1998, he visited the Mathematics Department, Texas Tech University, TX. In the fall of 2001, he visited the Mechanical Engineering Department, Princeton University, Princeton, NJ. From 2003 to 2012 he worked as a Senior researcher and Deputy Research Director with the Swedish Defence Research Agency (FOI). From january 2013 he is an Associated Professor in Robotics and Autonomous Systems, with the Computer Vision and Active Perception lab (CVAP) at KTH.

At FOI, Petter worked in several projects funded by the Swedish Airforce. One of these involved the design of a mixed initiative control system for UAVs, and another the design of cooperative air combat behaviors, that were implemented in the pilot training facility FLSC (Swedish Airforce Air Combat Simulation Center).

1. University degree
MSc in Engineering Physics, KTH, 1998

2. Doctoral degree
PhD in Optimization and Systems Theory, KTH, 2003

3. Visits to other universities
Mechanical and Aerospace Dep. Princeton University, USA, aug-dec 2001
Mathematics Dep. Texas Tech University, USA, aug-dec 1998

4. Docent level
Docent in Mathematics, Optimization and Systems Theory at KTH in 2010

5. Current employment
Associate Professor, Computer Vision and Active Perception, KTH

6. Previous employments
1999-2003 PhD student, Optimization and Systems Theory
2003-2009 Senior Scientist, Swedish Defence Research Agency (FOI)
2010-2012 Deputy Research Director in Autonomous Systems, FOI

7. Paternal leaves
15 months of 100 % paternity leave (May – November 2007, and Jan – August 2010)

8a. Supervision of PhD students

David Anisi, Graduated 2009 (co-supervisor)
Johan Thunberg, Graduated 2014 (co-supervisor)
Yuquan Wang (Main supervisor, started 2012)
Alejandro Marzinotto (co-supervisor, started 2013)
Michele Colledanchise (Main supervisor, started 2013)
Sergio Caccamo (co-supervisor, started 2014)
Fredrik Båberg (Main supervisor, started 2014)
Ivan Lundberg (Main supervisor, started 2014)

8b. Supervision of PostDocs

Ramviyas Paramasuraman (Main supervisor, started 2014)

9. Other Information

Grants

2014 co-PI, EU H2020 *SARAFun* (KTH budget 67PM)
2014 PI, CISB Project Seed Funding *ArBaWing* (budget 7000usd)
2013 PI, SSF Mobility Grant *RRAAA* (budget 1037kSEK)
2013 co-PI, EU FP7 IP *TRADR* (KTH budget 0.9MEuro)
2012 co-PI, Swedish Research Council "rambidrag": *CARMA*
2007 PI and Coordinator, FMV: *AURES* (overall budget 9M SEK)

Thesis Examinination, Grading Committee, Opponent

Stephan Huck, ETH Zurich, Control Theory, 2014 (grading committee, PhD thesis)
Aftab Ahmad, KTH, Machine Design, 2014 (grading committee, PhD thesis)
Tina Erlandsson, Örebro University, Information Technology, 2014 (Opponent, PhD thesis)
Simon Benjaminsson, KTH, CSC, 2013 (grading committee, PhD thesis)
Alberto Speranzon, KTH, S3, 2006 (grading committee, PhD thesis)

Program Committees assignments

Program Commite for the IAS
Program Commite for the SCAI
Associate Editor for the IEEE IROS
Associate Editor for Robotics: Science and Systems (RSS)

Reviewing

Theoretical Computer Science
IEEE Transactions on Automatic Control
IEEE Transactions on Robotics
IEEE Transactions on Control Systems Technology
IEEE International Conference on Robotics and Automation (ICRA)
IEEE Intelligent Robots and Systems (IROS)
IEEE Conference on Decision and Control (CDC)
American Control Conference (ACC) of the American Automatic Control Council
The European Control Conference (ECC)
International Federation of Automatic Control (IFAC) World Congress
IEE Proceedings on Control Theory and Applications

CURRICULUM VITAE

Mario Romero

KTH-CSC
School of Computer Science and Communication
10044 Stockholm
Mobile: +467 625 81 802
Email: marior@kth.se
URL: www.kth.se/profile/marior/

1. Higher education degrees

2001 Master in Computer Science, University of Illinois at Urbana-Champaign, USA
Area: Artificial Intelligence

1996 B.S. Construction Engineering (rank 1, cum laude)
B.S. Industrial Engineering (rank 2), Universidad San Francisco de Quito, Ecuador

2. Doctoral degree

2009 Ph.D. Computer Science, Georgia Institute of Technology, Atlanta, USA
Area: Human-Computer Interaction and Information Visualization.
Thesis: *Supporting Human Interpretation and Analysis of Activity Captured through Overhead Video.* Supervisor: Gregory Abowd

3. Postdoctoral positions (in reverse chronological order)

2012 Postdoctoral Researcher, Uppsala University, Department of Mathematics

2009-2012 Postdoctoral Research Fellow, Georgia Institute of Technology, Atlanta, USA
Principal investigator BrailleTouch. Director Child Study Laboratory.

4. Docent level - Lektor

5. Present positions

2013- Associate Professor, High-Performance Computing and Visualization, KTH
Teaching 50%, research 50% in Human-Computer Interaction and Visualization.

2012- Technical co-founder, BrailleTech LLC, Atlanta, USA
Advise research and development in accessible text entry soft keyboards.

6. Previous positions and periods of appointment (in reverse chronological order)

2012 Visiting Teacher, High-Performance Computing and Visualization, KTH
Advanced computer graphics and interaction in the Visualization Studio.

2008 Intern Research Scientist, Seagate Technologies, Pittsburgh, USA
Research: sensor networks, computer vision, visualization.

2003-2007 Mentor, Intel Opportunity Scholars Program, Georgia Tech, Atlanta, USA.

2004-2005 Coordinator, Intel Opportunity Scholars Program, Georgia Tech, Atlanta, USA.

2001-2009 Graduate Research Assistant, Georgia Institute of Technology, Atlanta, USA
Research: Human-Computer Interaction, visualization, computer vision.

1998-1999 Project Manager / Software Consultant, Grupo Microsistemas, Quito, Ecuador

1994-1997 Co-Founder/ Board Member/Teacher, Corporación Cultural Valdivia, Ecuador
Non-profit aimed at promoting academic advancement through technology.

1992-1997 Independent Graphic Designer, Quito, Ecuador

1995 Intern Plant Engineer, Pinturas Wesco / Polyacrilart, Quito, Ecuador

7. Service

SUPERVISION OF MS STUDENTS AND CO-SUPERVISION OF PHD STUDENTS

2014 - Hanna Hasselqvist, PhD student, Human-Computer Interaction, KTH
2014-2015 Joakim Rasmuson, M.S. student, Human-Computer Interaction, KTH
2014 Max Roth, M.S. student, Computer Science, KTH
2013-2014 Andreas Tarandi, M.S. student, Computer Science, KTH
2010- Paula Gomez, Ph.D. student, Design Computing, School of Architecture, Georgia Institute of Technology; co-supervisor
2010-2012 Caleb Southern, Ph.D. student, Human-Centered Computing, Georgia Institute of Technology; co-supervisor
2008-2011 Brian Frey, research volunteer; currently Ph.D. student, UMBC
2011 Esther Goh, M.S. Computer Science; currently at National Computer Systems
2011 Taeil Choi, M.S. Computer Science; currently at LG Electronics

AWARDED GRANTS

2013 **Small Visionary Grant**, KTH, CSC
Funded level: 570,000SEK
Principal Investigator: **Mario Romero**

2013 **Vinnova Forska&Väx**, Remote Data Visualization
SCISS AB, Stockholm, Sweden. Funded Level: 2,286,800 SEK over 1.5 years
Principal Investigator: Staffan Klashed

2012 **Rikbankens Jubileusfond**, Segregation: Mechanisms Micro-Macro Dynamics
Institutet för Framtidsstudier, Stockholm, Sweden
Award Number M12 0301: 1. Funded Level: 35 million SEK over 5 years
Principal Investigator: Peter Hedström

2011 **National Institute on Disability and Rehabilitation Research** (NIDRR), United States Department of Education
Rehabilitation Engineering Research Center for Wireless Technologies
Award Number H133E110002. Funded Level: $5,000,000 over 5 years
Principal Investigator: Helena Mitchell

2010 **National Science Foundation Expeditions in Computational Behavior Science**
Award Number 1029679, Funded Level: $10,000,000 over 5 years
Principal Investigator: Jim Rehg

1995 **Fuerza Aérea Ecuatoriana (FAE), Ecuadorian Air Force**
Academic Restructuring of the Ecuadorian Air Force Academy Cosme Renella, Salinas, Ecuador. Grant Amount: $400,000 over 2 years
Project Leader: Guiomar Vega, Corporación Cultural Valdivia

SELECT HONORS AND AWARDS

2015 Full Paper Honorable Mention, ACM CHI2015, Seoul, Korea
2014 Teacher of the Year Award, KTH School of Computer Science and Communication
2014 Winner, C-Awards Interaction Design, Flying Colors; People's Choice, Explore.fm
2013 Winner, C-Awards Next Public Magnet, MusiCube, Norrköping, Sweden
2011 First Place, Design Competition MobileHCI 2011, Stockholm, Sweden
2011 Best Paper Award, HCII 2011, Orlando, USA
2009 Tower Award, Georgia Institute of Technology, Atlanta, USA
1999 Fulbright Scholarship, Foreign Student Program, Quito, Ecuador
1999 Encyclopedia Britannica Scholarship
1996 Cum Laude (Rank 1 in Construction Engineering, Rank 2 in Industrial Engineering)

Publication list

Publications

Christopher Peters

For publication metrics, see Google scholar profile 'Christopher Edward Peters'

Five most relevant publications (in order of relevance)

[J10] Peters, C. and Ennis, C. "Modeling groups of plausible virtual pedestrians", IEEE Computer Graphics and Applications, Special Issue on Virtual Populace, vol. 29, no. 4, pp. 54 - 63, July/Aug, 2009

[J4] Ennis, C., Peters, C. and O' Sullivan, C. "Perceptual effects of scene context and viewpoint for virtual pedestrian crowds", ACM Transactions on Applied Perception, 8(2):10, February 2011

[C9] Carretero, M.R., Peters, C., Qureshi, A. "Modelling emotional behaviour in virtual crowds through expressive body movements and emotion contagion". SIGRAD, pp. 95-98, 2014

[C5] Carretero, M.R., Qureshi, A., Peters, C. "Evaluating the perception of group emotion from full body movements in the context of virtual crowds". In Proceedings of the ACM Symposium on Applied Perception (SAP '14). ACM, New York, NY, USA, pp. 7-14, 2014

[C14] O' Connor, S., Fialek, S., Roesch, E. and Peters, C. "Towards procedurally generated perceptually plausible inhabited virtual cities: A psychophysical investigation", Intelligent Agents in Urban Simulations and Smart Cities Workshop, ECAI 2012, Montpellier, France, August 2012

Peer reviewed journal articles

[J1] Ruhland, K., Peters, C.E., Andrist, S., Badler, J.B., Badler, N.I., Gleicher, M., Mutlu, B., McDonnell, R. "A review of eye gaze in virtual agents, social robotics and HCI: Behaviour generation, user interaction and perception", Computer Graphics Forum, Wiley-Blackwell, to appear 2015

[J2] Anderson, E.F., Peters, C.E., Halloran, J., Every, P., Shuttleworth, J., Liarokapis, F., Lane, R. and Richards, M. "In at the deep end: An activity-led six week challenge in creative computing", Computer Graphics Forum, Wiley-Blackwell, 31(6), pp. 1852-1866, 2012

[J3] Castellano, G., Mancini, M., Peters, C., and McOwan, P. W. "Expressive copying behavior for socially interacting machines: A perceptual analysis", IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, 42(3), pp. 776-783, May 2012

[J4] Ennis, C., Peters, C. and O' Sullivan, C. "Perceptual effects of scene context and viewpoint for virtual pedestrian crowds", ACM Transactions on Applied Perception, 8(2):10, February 2011

[J5] Anderson, E.F, McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P. and de Freitas, S. "Developing serious games for cultural heritage: a state-of-the-art review", Virtual Reality, Springer-Verlag Berlin Heidelberg, 14(4):255-275, December 2010

[J6] Panzoli, D., Peters, C., Dunwell, I., Sanchez, S., Petridis, P., Protopsaltis, A., Scesa, V., and de Freitas, S. "A level of interaction framework for exploratory learning with characters in virtual environments", Intelligent Computer Graphics: Studies in Computational Intelligence, Springer-Verlag Berlin Heidelberg, 321:123-143, 2010

[J7] Peters, C. and Qureshi, A. "A head movement propensity model for animating gaze shifts and blinks of virtual characters". Computers and Graphics, Elsevier, 2010

[J8] Castellano, G., and Peters, C. "Socially perceptive robots: Challenges and concerns", Commentary on the article: Sharkey, N., and Sharkey, A. "The crying shame of robot nannies: an ethical appraisal", Interaction Studies, John Benjamins Publishing Company, 11(2), pp. 201-207, John Benjamins Publishing Company, 2010

[J9] Peters, C., Asteriadis, S. and Karpouzis, K. "Investigating shared attention with a virtual agent using a gaze-based interface", Springer Journal on Multimodal User Interfaces (JMUI), Springer-Verlag Berlin Heidelberg, 2009

[J10] Peters, C. and Ennis, C. "Modeling groups of plausible virtual pedestrians", IEEE Computer Graphics and Applications, Special Issue on Virtual Populace, vol. 29, no. 4, pp. 54 - 63, July/Aug, 2009

Peer reviewed conference proceedings

[C1] Qureshi, A., Monk, R., Peters, C. "How do virtual agents and social context influence our own emotions?", HCI International, to appear 2015

[C2] Ruhland, K., Andrist, S., Badler, J. B., Peters, C.E., Badler, N.I., Gleicher, M., Mutlu, B., McDonnell, R. "Look me in the Eyes: A Survey of Eye and Gaze Animation for Virtual Agents and Artificial Systems"

[C3] Peters, C.E., Anderson, E.F., "The Four I's recipe for cooking up computer graphics exercises and assessments". Eurographics Education Papers, pp. 33-35, 2014

[C4] Mancini, M., Ermilov, A., Castellano, G., Liarokapis, F., Varni, G., Peters, C. "Effects of gender mapping on the perception of emotion from upper body movement in virtual characters". HCI International (16), pp. 263-273, 2014

[C5] Carretero, M.R., Qureshi, A., Peters, C. "Evaluating the perception of group emotion from full body movements in the context of virtual crowds". In Proceedings of the ACM Symposium on Applied Perception (SAP '14). ACM, New York, NY, USA, pp. 7-14, 2014

[C6] Qureshi, A., Peters, C., Apperly, I. "How does varying gaze direction affect interaction between a virtual agent and participant in an on-line communication scenario?", HCI International (16) 2014, pp. 305-316, 2014

[C7] Corrigan, L.J., Basedow, C., Küster, D., Kappas, A., Peters, C., Castellano, G. "Mixing implicit and explicit probes: finding a ground truth for engagement in social human-robot interactions". HRI 2014, pp. 140-141, 2014

[C8] Romero, M., Thuresson, B., Peters, C., Kis, F., Coppard, J., Andrée, J., Landazuri, N. "Augmenting PBL with large public presentations: a case study in interactive graphics pedagogy". ITiCSE 2014, pp. 15-20, 2014

[C9] Carretero, M.R. , Peters, C., Qureshi, A. "Modelling emotional behaviour in virtual crowds through expressive body movements and emotion contagion". SIGRAD, pp. 95-98, 2014

[C10] O' Connor, S., Liarokapis, F. and Peters, C. "An initial study to assess the perceived realism of agent crowd behaviour in a virtual city", 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games), September 2013

[C11] Corrigan, L., Peters, C., and Castellano, G. "Social-task engagement: Striking a balance between the robot and the task", Proceedings of the Workshop on Embodied Communication of Goals and Intentions, International Conference on Social Robotics, Bristol, United Kingdom, October 2013

[C12] Corrigan, L., Peters, C., and Castellano, G. "Identifying task engagement: Towards personalised interactions with educational robots", Proceedings of the Doctoral Consortium of the 5th HUMAINE Association Conference on Affective Computing and Intelligent Interaction (ACII'13), Geneva, Switzerland, September 2013

[C13] O' Connor, S., Liarokapis, F., and Peters, C. "A perceptual study into the behaviour of autonomous agents within a virtual urban environment", IEEE 14th International Symposium on A World of Wireless, Mobile and Multimedia Networks (WOWMOM 2013), Madrid, Spain, June 2013

[C14] O' Connor, S., Fialek, S., Roesch, E. and Peters, C. "Towards procedurally generated perceptually plausible inhabited virtual cities: A psychophysical investigation", Intelligent Agents in Urban Simulations and Smart Cities Workshop, ECAI 2012, Montpellier, France, August 2012

[C15] Morris, D., Anderson, E.F., and Peters, C. "A modular framework for deformation and fracture using GPU shaders", 18th International Conference on Virtual Systems and Multimedia (VSMM2012), IEEE Computer Society, September 2012

[C16] Mancini, M., Castellano, G., Peters, C. and McOwan, P.W. "Evaluating the communication of emotion via expressive gesture copying behaviour in an embodied humanoid agent", Proceedings of the 4th International Conference on Affective Computing and Intelligent Interaction (ACII), Springer Lecture Notes in Computer Science (LNCS), Springer-Verlag Berlin Heidelberg, Memphis, Tennessee, USA, 2011

[C17] Castellano, G., Mancini, M. and Peters, C. "Emotion communication via copying behaviour: A case study with the Greta embodied agent", in Proceedings of the AFFINE satellite workshop of the ACM ICMI 2011 Conference, Alicante Spain, November 17, 2011

[C18] Anderson, E.F., Peters, C., Liarokapis, F. and Halloran, J. "In at the deep end: An activity-led introduction to creative computing with interactive computer graphics", Eurographics 2011 - Education Papers, pp. 1-7, Wales, UK, April 2011

[C19] Peters, C., Qureshi, A. and Apperly, I.A. "Effects of gaze direction of a virtual agent in an online communication game", European Society of Philosophy and Psychology, Ruhr-Universitat Bochum, Germany, August 2010

[C20] Anderson, E.F. and Peters, C. "No more reinventing the virtual wheel: Middleware for use in computer games and interactive computer graphics education", Eurographics 2010 - Education Papers, pp. 33-40, Norrkoping, Sweden, May 2010

[C21] Panzoli, D., Peters, C., Dunwell, I., Sanchez, S., Petridis, P., Protopsaltis, A., Scesa, V., and de Freitas, S. "Adaptive User-Centric Experiences in Virtual Environments: Levels of Interactions", Proceedings of The 13th International Conference on Computer Graphics and Artificial Intelligence (3IA), Athens, Greece, May 2010

[C22] Peters, C. "Animating gaze shifts for virtual characters based on head movement propensity", IEEE sponsored International Conference on Games and Virtual Worlds for Serious Applications, Portugal, March 2010 ***Best Paper Award***

[C23] Panzoli, D., Peters, C., Dunwell, I., Sanchez, S., Petridis, P., Protopsaltis, A., Scesa, V., and de Freitas, S. "Levels of interaction: A user-guided experience in large-scale virtual environments", IEEE sponsored International Conference on Games and Virtual Worlds for Serious Applications, Short papers, Portugal, March 2010

[C24] Peters, C. "An object-based memory for supporting attentive virtual agents", Artificial Intelligence and the Simulation of Behaviour Convention (AISB), Symposium: Remembering Who We Are – Human Memory For Artificial Agents, De Montfort University, Leicester, March 29, 2010

[C25] Peters, C., Castellano, G. and de Freitas, S. "An exploration of user engagement in HCI", Proceedings of the Affect-Aware Virtual Agents and Social Robots (AFFINE) Workshop, International Conference on Multimodal Interfaces and Workshop on Machine Learning for Multimodal Interaction (ICMI-MLMI'09), Boston, MA, USA, November 6, 2009

[C26] Peters, C., Dunwell, I., de Freitas, S., Panzoli, D., Graf, B., Tscheligi, M., Burden, D., Duthen, Y. and Bonnell, B. "VIOLA: Concept of a new cognitive framework to enhance the capabilities of interactive service robots using virtual worlds", Beyond Gray Droids workshop: Domestic Robot Design for the 21st Century, Cambridge, UK, September 2009

[C27] Anderson, E.F. and Peters, C. "On the provision of a comprehensive computer graphics education in the context of computer games", Computer Graphics Education Workshop, Eurographics, March 2009

[C28] Peters, C. and O' Sullivan, C. "MetroPed: A tool for supporting crowds of pedestrian AI's in urban environments", Proceedings of Artificial Intelligence and the Simulation of Behaviour (AISB), Symposium: AI and Games, Edinburgh, Scotland, 2009

[C29] Anderson, E. F., McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P. and de Freitas, S. "Serious games in cultural heritage", VAST 2009: 10th International Symposium on Virtual

Reality, Archaeology and Cultural Heritage - VAST-STAR, Short Paper and Project Proceedings, pp. 29-48, Faculty of ICT, University of Malta, 2009

[C30] Anderson, E.F. and Peters, C. "On the provision of a comprehensive computer graphics education in the context of computer games", Eurographics 2009 - Education Papers, pp. 7-14, Eurographics Association, Munich, Germany, March 2009

[C31] Peters, C., Ennis, C., McDonnell R., and O' Sullivan, C. "Crowds in context: Evaluating the perceptual plausibility of pedestrian orientations", In Short Papers Proceedings of Eurographics 2008, Crete, Greece, 2008

[C32] Peters, C., Asteriadis, S., Karpouzis, K., and de Sevin, E. "Towards a real-time gaze-based shared attention for a virtual agent", Workshop in Affective Interaction in Natural Environments, AFFINE, Satellite Workshop of the ACM International Conference on Multimodal Interfaces (ICMI), Crete, October 2008

[C33] Ennis, C., Peters, C., and O' Sullivan, C. "Perceptual evaluation of position and orientation context rules for pedestrian formations", APGV'08: Proceedings of the 5th ACM SIGGRAPH Symposium on Applied Perception in Graphics and Visualization, Los Angeles, CA, pp. 75-82, August 2008

[C34] Peters, C., and Grandjean, D. "A visual novelty detection component for virtual agents", In T. J. Paletta, L., editor, Proceedings of the Fifth International Workshop on Attention and Performance in Computational Vision (WAPCV), pp. 289-300, Santorini, Greece, May 2008

Book chapters

[B1] Castellano, G., Gunes, H., Peters, C., and Schuller, B. "Multimodal affect recognition for naturalistic human-computer and human-robot interactions", Invited chapter for Handbook of Affective Computing. R. A. Calvo, S. D'Mello, J. Gratch, A. Kappas (eds.), Oxford University Press, 2015

[B2] Peters, C., Castellano, G., Rehm, M., Andre, E., Volpe, G., Camurri, A., Raouzaiou, A., Rapantzikos, K., Karpouzis, K., and Vasalou, A. "Fundamentals of agent perception and attention modelling". In P. Petta, C. Pelachaud and R. Cowie (Eds.), Emotion-Oriented Systems: The Humaine Handbook, pp. 293-319, Cognitive Technologies Series, Springer, January 2011

[B3] Douglas-Cowie, E., Cox, C., Martin, J-C., Devillers, L., Cowie, R., Sneddon, I., McRorie, M., Pelachaud, C., Peters, C., Lowry, O., Batliner, A., and Hoenig, F. "The HUMAINE database". In P. Petta, C. Pelachaud and R. Cowie (Eds.), Emotion-Oriented Systems: The Humaine Handbook, pp. 243-284, Cognitive Technologies Series, Springer, January 2011

[B4] Grandjean, D., and Peters, C. "Novelty processing and emotion: conceptual developments, empirical findings and virtual environments". In P. Petta, C. Pelachaud and R. Cowie (Eds.), Emotion-Oriented Systems: The Humaine Handbook, pp. 441-458, Cognitive Technologies Series, Springer, January 2011

[B5] Andre, E., Bevacqua, E., Heylen, D., Niewiadomski, R., Poggi, I., Pelachaud, C., Peters, C., and Rehm, M. "Non-verbal persuasion and communication in an affective agent". In P. Petta, C. Pelachaud and R. Cowie (Eds.), Emotion-Oriented Systems: The Humaine Handbook, pp. 585-608, Cognitive Technologies Series, Springer, January 2011

[B6] Krenn, B., Pelachaud, C., Pirker, H., and Peters, C. "Embodied conversational characters: representation formats for multimodal communicative behaviours". In P. Petta, C. Pelachaud and R. Cowie (Eds.), Emotion-Oriented Systems: The Humaine Handbook, pp. 389-415, Cognitive Technologies Series, Springer, January 2011

[B7] Bevacqua, E., Mancini, M., Peters, C., Ochs, M., Chafai, N.E., and Pelachaud, C. "Abilita socio-emotive per agenti virtuali dedicati all'e-learning", E. Magno-Caldognetto and F. Cavicchio Eds, Aspetti emotivi e relazionali nell'e-learning, Firenze University Press, 2008

Editorials

[E1] Castellano, G., Karpouzis, K., Morency, L.-P., Martin, J.-C., Peters, C., and Riek, L. "The 5th International Workshop on Affective Interaction in Natural Environments (AFFINE): Interacting with Affective Artefacts in the Wild". Proceedings of the 5th HUMAINE Association Conference on Affective Computing and Intelligent Interaction (ACII'13), Geneva, Switzerland, September 2013

[E2] Castellano, G., Riek, L., Peters, C., Karpouzis, K., Martin, J.-C., and Morency, L.-P. "Introduction to the special issue on affective interaction in natural environments". ACM Transactions on Interactive Intelligent Systems (TiiS), 2(1), pp. 1-4, March 2012

[E3] Peters, C. Section "Emotion in interaction". In P. Petta, C. Pelachaud, and R. Cowie (Eds.), Emotion-Oriented Systems: The Humaine Handbook, Springer, January 2011

[E4] Castellano, G., Karpouzis, K., Morency, L.-P., Martin, J.-C., Peters, C., and Riek, L. "The 3rd international workshop on AFFective Interaction in Natural Environments (AFFINE)". Proceedings of the ACM International Conference on Multimedia, Florence, Italy, October 2010

[E5] Castellano, G., Karpouzis, K., Peters, C., and Martin, J.-C. "Special Issue on Real-time affect analysis and interpretation: Closing the affective loop in virtual agents and robots". Journal on Multimodal User Interfaces, Springer-Verlag Berlin Heidelberg, 3(1-2,1-3), 2010

Non refereed invited publications

[N1] Shuttleworth, J., Every, P., Anderson, E., Halloran, J., Peters, C., and Liarokapis, F. "Press play: An experiment in creative computing using a novel pedagogic approach", AngloHigher, ISSN 2041-8469, Volume 2, Issue 1, pp.23-24, Jan 2010

[N2] Peters, C. Asteriadis, S. and Rebolledo-Mendez, G. "Modelling user attention for human-agent interaction", Invited Workshop: WIAMIS International Workshop on Image Analysis for Multimedia Interactive Services, 2009

Popular science presentations

[S1] Invited speaker (internal seminar): "The Computational Beauty of Human Behaviour: A Perceptual Approach to Crowd Simulation". Computational Science and Engineering Centre(KCSE), KTH Royal Institute of Technology, Sweden, March 2013.

[S2] Invited speaker: "The Future of Gaming". IET (Institution of Engineering and Technology) Christmas Lecture. In collaboration with Dr. Eike Anderson (University of Bournemouth) and Dr. Fotis Liarokapis (Coventry University), Birmingham, UK, 2012.

[S3] Invited speaker: "Mind-minding Machines". In collaboration with Prof. Ian Apperly, (University of Birmingham), Dr. Sam Gilbert (University College London) and Prof. Stephen Butterfill (University of Warwick) as part of a seminar on "Mind-reading: Humans, Brain Scanners and Computers", British Science Festival, Bradford, UK 2011.

List of Publications

MOST CITED PUBLICATIONS

Citation database used: Google Scholar (2015-03-26)

1. P. Ögren, E. Fiorelli, N.E. Leonard, Cooperative Control of Mobile Sensor Networks:Adaptive Gradient Climbing in a Distributed Environment, *IEEE Transactions on Automatic Control*, Vol. 49, No. 8, August 2004.
   Number of citations: 877

2. P. Ögren, M. Egerstedt and X. Hu: A Control Lyapunov Function Approach to Multi-Agent Coordination, *IEEE Transactions on Robotics and Automation*, pages 847-852, October 2002.
   Number of citations: 397

3. P. Ögren, E. Fiorelli, and N. E. Leonard: "Formations with a Mission: Stable Coordination of Vehicle Group Maneuvers Proc. " *15th International Symposium on Mathematical Theory of Networks and Systems*, 2002.
   Number of citations: 197

4. P. Ögren and N. Leonard: A Convergent Dynamic Window Approach to Obstacle Avoidance, *IEEE Transactions on Robotics and Automation*, Vol 21, No 2, April 2005.
   Number of citations: 157

5. P. Ögren and N. Leonard: "Obstacle Avoidance in Formation, " *IEEE International Conference on Robotics and Automation*, Taipei, Taiwan, 2003.
   Number of citations: 120

1. REFEREED JOURNAL ARTICLES

1. P. Ögren, P. Svenmarck and P. Lif, Design and Implementation of a New Teleoperation Control Mode for Differential Drive UGVs, Journal of Autonomous Robots, 2014. Number of citations: 1

2. J. Robinson and P. Ögren, On The Use of Gradual Dense Sparse Discretizations in Receding Horizon Control, *Optimal Control, Applications and Methods*, 2013. DOI: 10.1002/oca.2065. Number of citations: 2

3. J. Thunberg, P. Ögren, A Mixed Integer Linear Programming approach to Pursuit Evasion Problems with optional Connectivity Constraints, *Journal of Autonomous Robots*, 2011. DOI: 10.1007/s10514-011-9247-y. Number of citations: 7

4. P. Ögren, J.W.C. Robinson, A Model Based Approach to Modular Multi-Objective Robot Control, *Journal of Intelligent and Robotic Systems*, Volume 63, Number 2, 257-282, 2011. DOI: 10.1007/s10846-010-9523-7. Number of citations: 4

5. D. Anisi, P. Ögren, X. Hu, Cooperative Minimum Time Surveillance with Multiple Ground Vehicles, *IEEE Transactions on Automatic Control*, vol 55, (2679 - 2691), December 2010. Number of citations: 16

6. P. Ögren and M. Winstrand, Minimizing Mission Risk in Fuel Constrained UAV Path Planning, *AIAA Journal of Guidance, Control, and Dynamics*, vol.31 no.5 (1497-1500) 2008. Number of citations: 3

2. REFEREED CONFERENCE ARTICLES

1. M Colledanchise, P Ögren, How Behavior Trees modularize robustness and safety in hybrid systems, *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2014. Number of citations: 3

2. I Lundberg, M Bjorkman, P Ögren, Intrinsic camera and hand-eye calibration for a robot vision system using a point marker, *IEEE-RAS International Conference on Humanoid Robots (Humanoids)*, 2014. Number of citations: 0

3. Y Wang, M. Colledanchise, A. Marzinotto, P. Ögren, A Distributed Convergent Solution to the Ambulance Positioning Problem on a Streetmap Graph, *IFAC World Congress*, Cape Town, South Africa, 2014. Number of citations: 0

4. Y Wang, F Eli Vina, Y Karayiannidis, C Smith, Petter Ögren, Dual Arm Manipulation Using Constraint Based Programming, *IFAC World Congress*, Cape Town, South Africa, 2014. Number of citations: 0

5. M Colledanchise, A Marzinotto. P. Ögren, Performance Analysis of Stochastic Behavior Trees *IEEE International Conference on Robotics and Automation (ICRA)* Hong Kong, China, 2014. Number of citations: 6

6. A Marzinotto, M Colledanchise, C Smith, P. Ögren, Towards a Unified Behavior Trees Framework for Robot Control *IEEE International Conference on Robotics and Automation (ICRA)* Hong Kong, China, 2014. Number of citations: 10

7. M Colledanchise, DV Dimarogonas, P Ögren, Obstacle avoidance in formation using navigation-like functions and constraint based programming *IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2013. Number of citations: 1

8. Y. Karayiannidis, C. Smith, P. , F. Vina, Ögren, D. Kragic, Model-free robot manipulation of doors and drawers by means of fixed-grasps, *IEEE International Conference on Robotics and Automation (ICRA)* Karlsruhe, Germany, 2013. Number of citations: 4

9. Y. Karayiannidis, C. Smith, F. Vina, P. Ögren, and D. Kragic. "Design of force-driven online motion plans for door opening under uncertainties," Workshop on Real-time Motion Planning: Online, Reactive, and in Real-time, *IEEE/RSJ International Conference on Intelligent Robots and Systems*, October 12, 2012 Vilamoura, Portugal Number of citations: 0

10. Y. Karayiannidis, C. Smith, F. Vina, P. Ögren, and D. Kragic. "Open Sesame!" - Adaptive Force/Velocity Control for Opening Unknown Doors," *IEEE/RSJ International Conference on Intelligent Robots and Systems*, October 7-12, 2012 Vilamoura, Portugal, pp. 4040-4047 Number of citations: 10

11. P. Ögren, "Increasing Modularity of UAV Control Systems using Computer Game Behavior Trees, " *AIAA conference on Guidance, Navigation and Control* 2012. Number of citations: 11

12. P. Ögren, C. Smith, Y. Karayiannidis, D. Kragic, "A Multi Objective Control Approach to Online Dual Arm Manipulation, " *International IFAC Symposium on Robotic Control* 2012. Number of citations: 4

13. Y. Karayiannidis, C. Smith, P. Ögren, D. Kragic, "Adaptive Force/Velocity Control for Opening Unknown Doors, " *International IFAC Symposium on Robotic Control* 2012. Number of citations: 4

14. J. Thunberg, X. Hu, P. Ögren, "A Boolean Control Network Approach to Pursuit Evasion Problems in Polygonal Environments, " *IEEE International Conference on Robotics and Automation (ICRA)*, Shanghai, China, May 2011. Number of citations: 0

15. P. Ögren, J.W.C. Robinson, "Receding Horizon Control of UAVs using Gradual Dense-Sparse Discretizations, " *AIAA Conference on Guidance, Navigation and Control*, Toronto, Canada, August, 2010. Number of citations: 3

16. J. Thunberg, P. Ögren, "An Iterative Mixed Integer Linear Programming Approach to Pursuit Evasion Problems in Polygonal Environments, " *IEEE International Conference on Robotics and Automation (ICRA)*, Anchorage, Alaska, May 2010. Number of citations: 9

17. D.A. Anisi, T. Lindskog and P. Ögren, "Algorithms for the connectivity constrained unmanned ground vehicle surveillance problem, " *European Control Conference (ECC)*, Budapest, Hungary, Aug., 2009. Number of citations: 2

18. D. Anisi, P. Ögren and X. Hu, "Cooperative surveillance missions with multiple UGVs, " *IEEE Conference on Decision and Control (CDC)*, Cancun, Mexico, December 2008. Number of citations: 7

19. P. Ögren, "Improved predictability of reactive robot control using Control Lyapunov Functions, " *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Nice, France, 2008. Number of citations: 5

20. U. Nilsson, P. Ögren, J. Thunberg, "Optimal positioning of surveillance UGVs, " *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Nice, France, 2008. Number of citations: 9

5. BOOK CHAPTERS

1. D. Anisi and P. Ögren, "Minimum time multi-UGV surveillance," *in Springer Lecture notes in Control and Information Sciences: Optimization and Cooperative Control Strategies*, M.J. Hirsch, C.W. Commander, P.M. Pardalos, and R. Murphey (Eds), Pages 31-45, 2008. Number of citations: 7

2. U. Nilsson, P. Ögren and J. Thunberg, "Towards Optimal Positioning of Surveillance UGVs, " *in Springer Lecture notes in Control and Information Sciences: Optimization and Cooperative Control Strategies*, M.J. Hirsch, C.W. Commander, P.M. Pardalos, and R. Murphey (Eds), Pages 221-233, 2008. Number of citations: 3

3. J. Thunberg, D. Anisi, and P. Ögren, "A comparative study of task assignment and path planning methods for multi-UGV missions, " *in Springer Lecture notes in Control and Information Sciences: Optimization and Cooperative Control Strategies*, M.J. Hirsch, C.W. Commander, P.M. Pardalos, and R. Murphey (Eds), Pages 167-180, 2008. Number of citations: 3

6. PATENTS

P. Ögren holds a number of patents covering a new Method for Teleoperating an Unmanned Ground Vehicle With a Pan Camera. US patent 8,386,089, Swedish patent SE0600352-9, Canadian patent 2,642,591

Peer-Reviewed Journal Publications (reverse chronological order; J – Journal)

[J1] Nazneen, Rozga, A., **Romero, M.**, Findley, A., Call, C., Abowd, G., and Arriaga, R. (2011), "Supporting Parents for in-Home Capture of Problem Behaviors of Children with Developmental Disabilities," in Journal of Personal and Ubiquitous Computing, Springer London: 2011. On pages: 193 – 207.

[J2] Shin, G., Choi, T., Rozga, A., and **Romero, M.** (2011), "VizKid: A Behavior Capture and Visualization System of Adult-Child Interaction." Human Interface and the Management of Information. Interacting with Information. Lecture Notes in Computer Science. Volume 6772/2011. Springer Berlin / Heidelberg: 2011. On pages: 190 – 198.

[J3] Frey, B., Southern, C., and **Romero, M.** (2011), "BrailleTouch: Mobile Texting for the Visually Impaired," in Universal Access in Human Computer Interaction. Context Diversity. Lecture Notes in Computer Science. Volume: 6767/2011. Springer Berlin / Heidelberg: 2011. On pages: 19 – 25.

[J4] **Romero, M.**, Summet, J., Stasko, J., and Abowd, G. (2008), "Viz-A-Vis: Toward Visualizing Video through Computer Vision," in IEEE Transactions on Visualization and Computer Graphics, Volume: 14, Issue: 6. Research Triangle Park, NC, USA: Nov.-Dec. 2008. On pages: 1261 – 1268.

[J5] **Romero, M.**, Pousman, Z., and Mateas, M. (2008), "Alien Presence in the Home: The Design of Tableau Machine," in Journal of Personal and Ubiquitous Computing. Volume: 12, Issue: 5. Springer London: June 2008. On pages: 373 – 382.

Peer-Reviewed Conference Proceedings (C – Conference)

[C1] Munteanu, C., Molyneaux, H., Moncur, W., **Romero, M.**, O'Donnell, S., Vines, J. (2015), "Situational Ethics: Re-thinking Approaches to Formal Ethics Requirements for Human-Computer Interaction", in Proceedings of the 2015 Annual Conference on Human Factors in Computing Systems, (CHI2015), April 18-23, 2015, Seoul, Korea.

[C2] Griggio, C., **Romero, M.**, Leiva, G. (2015), "Towards an Interactive Dance Visualization for Inspiring Coordination Between Dancers", in Extended Abstracts of the 2015 Annual Conference on Human Factors in Computing Systems, (CHI2015), April 18-23, 2015, Seoul, Korea.

[C3] Hasselqvist, H., **Romero, M.**, Bogdan, C., Shafqat, O. (2015), "Supporting Energy Management as a Cooperative Amateur Activity", in Extended Abstracts of the 2015 Annual Conference on Human Factors in Computing Systems, (CHI2015), April, April 18-23, 2015, Seoul, Korea.

[C4] Griggio, C., **Romero, M.**, (2015), "A real-time dance visualization framework for the design of mappings that favor user appropriation" in ACM Womencourage, September 24-26, Uppsala, Sweden.

[C5] **Romero, M.**, Thuresson, T., Peters, C., Landázuri, N., (2015), "Expo-Based Learning (EBL): Augmenting Project-Based Learning with Large Public Presentations", in KTH Scholarship of Teaching and Learning, March 11, 2015, Stockholm, Sweden.

[C6] Griggio, C., **Romero, M.**, (2015), "Canvas Dance: An Interactive Dance Visualization for Large-Group Interaction", in Interactivity at the 2015 Annual Conference on Human Factors in Computing Systems, (CHI2015), April, April 18-23, 2015, Seoul, Korea.

[C7] **Romero, M.**, Thuresson, B., Peters, C., Kis, P., Coppard, J., Andrée, J., Landázuri, N. (2014), "Augmenting PBL with Large Public Presentations: A Case Study in Interactive Graphics Pedagogy" in ITiCSE 2014, 19th Annual Conference on Innovation and Technology in Computer Science Education, June 23-25, 2014, Uppsala, Sweden.

[C8] **Romero, M.**, Hasselqvist, H., Svensson, G. (2014), "Supercomputers Keeping People Warm in the Winter", in ICT for Sustainability 2014 (ICT4S-14), August 24-27, 2014, Stockholm, Sweden.

[C9] **Romero, M.** (2014), "Flat is the New Pitch-Black: Discussing Blind use of Touchscreens" in Tactile UX, Workshop on Tactile User Experience Evaluation Methods at CHI2014, Toronto, Canada.

[C10] **Romero, M.** (2014), "Designing and Evaluating Embodied Sculpting: a Touching Experience", in Tactile UX, Workshop on Tactile User Experience Evaluation Methods at CHI2014, Toronto, Canada.

[C11] Gómez, P., Do, E.Y.L., **Romero, M.** (2015), “La forma de las actividades humanas en el espacio: hacia un análisis espacio-temporal en la arquitectura” in De Arquitectura, Issue 26. On pages 11-19.

[C12] Rehg J., Abowd, G., Rozga, A., **Romero M.**, Clements, M., Sclaroff, S., Essa, I., Ousley, O., Li, Y., Kim, C., Rao, H., Kim, J., Presti, L., Zhang, J., Lantsman, D., Bidwell, J., Zhefan, Y. (2013), “Decoding Children's Social Behavior,” in IEEE Conference on Computer Vision and Pattern Recognition - CVPR 2013, Portland, USA: June 23-28. On pages: TBD.

[C13] **Romero, M.** (2013), “Project-Based Learning of Advanced Computer Graphics and Interaction,” in EUROGRAPHICS 2013. Girona, Spain: May 6-10. On pages: 1-6.

[C14] Southern, C., Clawson, J., Frey, B., Abowd, G., and **Romero, M.** (2012), “An Evaluation of BrailleTouch: Mobile Touchscreen Text Entry for the Visually Impaired,” in MobileHCI 2012. San Francisco, USA: September 21-24. On pages: 317 – 326.

[C15] Frey, B., Southern, C., Rosier, K., and **Romero, M.** (2012), "From Texting App to Braille Literacy," in Proceedings of the 2012 Annual Conference on Human Factors in Computing Systems, Extended Abstracts (CHI 2012). Austin, USA: May 5-10. On pages: 2495 – 2500.

[C16] Gomez, P., **Romero, M.**, and Do, E.Y.L. (2012), “Activity Shapes: Analysis Methods of Video-Recorded Human Activity in a Co-visible Space,” in Space Syntax Symposium (SSS8), Santiago, Chile: January 2012. (20-page online journal).

[C17] **Romero, M.**, Frey, B., Southern, C., and Abowd, G. (2011), "BrailleTouch: Designing a Mobile Eyes-Free Soft Keyboard," in MobileHCI 2011, Design Competition. Stockholm, Sweden: August 30-September 2. On pages: 707-709. **Design competition winner.**

[C18] **Romero, M.**, Vialard, A., Peponis, J., Stasko, J., and Abowd, G. (2011), "Evaluating Video Visualizations of Human Behavior," in Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems, (CHI 2011). Vancouver, Canada: May 7-12. On pages: 1441 – 1450.

[C19] Kinnaird, P. and **Romero, M.** (2010), "Focus Groups for Functional InfoVis Prototype Evaluation: A Case Study." Beyond Times and Errors: Novel Evaluation Methods for Information Visualization, BELIV 2010, Atlanta: April 2010. (2-page publication).

[C20] Kinnaird, P., **Romero, M.**, and Abowd, G. (2010), "Connect2Congress: Visual Analytics for Civic Oversight," in Proceedings of the 2010 Annual Conference on Human Factors in Computing Systems (CHI 2010), Atlanta: April 10-15. On pages: 2853 – 2862.

[C21] Pousman, Z., **Romero, M.**, Smith, A., and Mateas, M. (2008), "Living with Tableau Machine: A Longitudinal Investigation of a Curious Domestic Intelligence," in Proceedings of the 10th International Conference on Ubiquitous Computing (UbiComp08). Seoul, Korea: September 21-24. On pages: 370 – 379.

[C22] Smith, A., **Romero, M.**, Pousman, Z., and Mateas, M. (2008), "Tableau Machine: A Creative Alien Presence," in AAAI Creative Intelligent Systems Symposium, Stanford: March 26-28. On pages: 82 – 89.

[C23] Berrada, D., **Romero, M.**, Abowd, G., Blount, M., and Davis, J. (2007), "Automatic Administration of the Get Up and Go Test," in International Conference on Mobile Systems, Applications and Services. Proceedings of the 1st International Workshop on Systems and Networking Support for Healthcare and Assisted Living Environments (SIGMOBILE 07). San Juan, Puerto Rico: June 11. On pages: 73 – 75.

[C24] **Romero, M.**, Pousman, Z., and Mateas, M. (2006), "Tableau Machine: An Alien Presence in the Home," in Proceedings of the 2006 Annual Conference on Human Factors in Computing Systems, Extended Abstracts (CHI 2006). Montreal, Canada: April 24-27. On pages: 1265 – 1270.

[C25] **Romero, M.** and Mateas, M. (2005), "A Preliminary Investigation of Alien Presence" in Proceedings of Human-Computer Interaction International (HCII 05). Las Vegas, USA: July 22-27. (9-page publication).

[C26] **Romero, M.** and Bobick, A. (2004), "Tracking Head Yaw by Interpolation of Template Responses." Face Processing in Video, Washington, DC. In the Proceedings of IEEE Conference on Computer Vision and Pattern Recognition (CVPR 04), Washington D.C., USA: June 27-July22. On pages: 83 – 90.

Patents and Invention Disclosures (P – Patents)

[P1] Georgia Tech Research Center Invention Disclosure No: 5500-61/421,423 - 12/9/2010
BrailleTouch: Eyes Free Mobile Texting on a Soft Multi-Touch Keyboard
Mario Romero (Principal Investigator), Caleb Southern, Brian Frey
Georgia Institute of Technology, Atlanta, USA

Open Access Computer Programs and Mobile Applications (A – Applications)

[A1] Rasmuson, J., **Romero, M**., http://flyingcolors3d.com/, Flying Colors, March 20, 2015. Entertainment iOS app – Apple ID 943250282.

[A2] Rasmuson, J., Hernandez, P., Hellström, F., **Romero, M**., http://musicube.se/, MusiCube, September 13, 2013. Music iOS app – Apple ID 703629900.

[A3] Southern, C., Frey, B., Abowd, G., Lynch, A., **Romero, M.** brailletouchapp.com
BrailleTouch by BrailleTech LLC. World release: January 31, 2013. Productivity iOS app – Apple ID 579725651

Select Popular Science and Media Coverage (M – Media)

[M1] "De utvecklar spel för säkrare vägar," **Stockholm METRO**, Emmelie Wallroth, 27 november 2013
http://touch.metro.se/nyheter/de-utvecklar-spel-for-sakrare-vagar/EVHmkA!v61DEBTL0Kt8Y/

[M2] "BrailleTouch," The Tech Doctor, Dr. Robert Carter and Allison Hartley, February 6, 2013

[M3] "An Interview with the Developer of BrailleTouch," Michael Hansen, AppleVis, January 5, 2013

[M4] "BrailleTouch," Macneticos Podcast and Youtube video, January 25, 2013

[M5] "BrailleTouch ayudará a los no videntes," Mario Romero, Revista USFQ Alumni, November, 2012

[M6] "Eye Story: BrailleTouch," Urmilla Prabhu, Ocular Times, September, 2012

[M7] "Teclado para ciegos," Café CNN, **CNN en Español**, February 28, 2012
http://cnn.com/video/?/video/spanish/2012/02/28/cafe-voice-over-intv-mpg.cnn

[M8] "Developer shows braille for smartphones," CNN Newsroom, **CNN**, February 25, 2012
http://cnn.com/video/?/video/bestoftv/2012/02/25/nr-smartphone-braille-keyboard.cnn

[M9] "Could BrailleTouch app revolutionize texting?" Deborah Netburn, **LA Times**, February 20, 2012
http://www.latimes.com/business/technology/la-fi-tn-braille-touch-blind-texting-20120220,0,2817977.story

[M10] "App helps blind to send text messages," **BBC**, February 20, 2012.
http://www.bbc.co.uk/news/technology-17105225

[M11] "BrailleTouch at the Abilities Expo 2012," live broadcast during 11Alive (**NBC**) Atlanta & Co., Atlanta, USA – February 13, 2012. Invited by Pullara, C. http://bcove.me/5n9m8a15

CV

Name: Christopher Peters	**Doctorial degree:** 2004-03-10
Birthdate: 19761218	**Academic title:** Docent
Gender: Male	**Employer:** Kungliga Tekniska högskolan

Research education

Dissertation title (swe)
Bottom-up visuell uppmärksamhet för autonom virtuell människa animation

Dissertation title (en)
Bottom-up visual attention for autonomous virtual human animation

Organisation	Unit	Supervisor
Trinity College Dublin, Ireland Not Sweden - Higher Education institutes	Image Synthesis Group, Department of Computer Science and Statistics	Prof. Carol O' Sullivan

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
10201. Datavetenskap (datalogi)		2004-03-10

CV

Name: Mario Romero	**Doctorial degree:** 2009-08-01
Birthdate: 19730808	**Academic title:** Docent
Gender: Male	**Employer:** Kungliga Tekniska högskolan

Research education

Dissertation title (swe)
Stöd mänsklig tolkning och analys av verksamheten fångas genom overhead video

Dissertation title (en)
Supporting Human Interpretation and Analysis of Activity Captured through Overhead Video

Organisation	Unit	Supervisor
Georgia Institute of Technology, USA Not Sweden - Higher Education institutes	College of Computing	Gregory Abowd

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
10204. Människa-datorinteraktion (interaktionsdesign) (Samhällsvetenskapliga aspekter under 50803)	978-1-109-45250-1	2009-08-01

CV

Name: Petter Ögren	**Doctorial degree:** 2003-06-06
Birthdate: 19740912	**Academic title:** Docent
Gender: Male	**Employer:** No current employer

Research education

Dissertation title (swe)

Dissertation title (en)

Formation and Obstacle Avoidance in Mobile Robot Control

Organisation	Unit	Supervisor
Kungliga Tekniska Högskolan, Sweden Sweden - Higher education Institutes	Institutionen för Matematik	Xiaoming Hu

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
10199. Annan matematik	9172835214	2003-06-06

Publications

Name: Christopher Peters	**Doctorial degree:** 2004-03-10
Birthdate: 19761218	**Academic title:** Docent
Gender: Male	**Employer:** Kungliga Tekniska högskolan

Peters, Christopher has not added any publications to the application.

Publications

Name: Mario Romero	**Doctorial degree:** 2009-08-01
Birthdate: 19730808	**Academic title:** Docent
Gender: Male	**Employer:** Kungliga Tekniska högskolan

Romero, Mario has not added any publications to the application.

Publications

Name: Petter Ögren	**Doctorial degree:** 2003-06-06
Birthdate: 19740912	**Academic title:** Docent
Gender: Male	**Employer:** No current employer

Ögren, Petter has not added any publications to the application.

Register

Terms and conditions

The application must be signed by the applicant as well as the authorised representative of the administrating organisation. The representative is normally the department head of the institution where the research is to be conducted, but may in some instances be e.g. the vice-chancellor. This is specified in the call for proposals.

The signature*from the applicant*confirms that:

- the information in the application is correct and according to the instructions form the Swedish Research Council
- any additional professional activities or commercial ties have been reported to the administrating organisation, and that no conflicts have arisen that would conflict with good research practice
- that the necessary permits and approvals are in place at the start of the project e.g. regarding ethical review.

The signature *from the administrating organisation* confirms that:

- the research, employment and equipment indicated will be accommodated in the institution during the time, and to the extent, described in the application
- the institution approves the cost-estimate in the application
- the research is conducted according to Swedish legislation.

The above-mentioned points must have been discussed between the parties before the representative of the administrating organisation approves and signs the application.

Project out lines are not signed by the administrating organisation. The administrating organisation only sign the application if the project outline is accepted for step two.

Applications with an organisation as applicant is automatically signed when the application is registered.