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Activity Report 2013

Project-Team Prima

Perception, recognition and integration for smart spaces

IN COLLABORATION WITH: Laboratoire d'Informatique de Grenoble (LIG)

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
**Vision, perception and multimedia
interpretation**

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Project-Team Prima

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2. Overall Objectives

2.1. Perception, Recognition and Multimodal Interaction for Smart Spaces.

The objective of Project PRIMA is to develop the scientific and technological foundations for human environments that are capable of perceiving, acting, communicating, and interacting with people in order to provide services. The construction of such environments offers a rich set of problems related to interpretation of sensor information, learning, machine understanding, dynamic composition of components and man-machine interaction. Our goal is make progress on the theoretical foundations for perception and cognition, as well as to develop new forms of man machine interaction, by using interactive environments as a source of example problems.

An environment is a connected volume of space. An environment is said to be “perceptive” when it is capable of recognizing and describing things, people and activities within its volume. Simple forms of applications-specific perception may be constructed using a single sensor. However, to be general purpose and robust, perception must integrate information from multiple sensors and multiple modalities. Project PRIMA creates and develops machine perception techniques fusing computer vision, acoustic perception, range sensing and mechanical sensors to enable environments to perceive and understand humans and human activities.

An environment is said to be “active” when it is capable of changing its internal state. Common forms of state change include regulating ambient temperature, acoustic level and illumination. More innovative forms include context-aware presentation of information and communications, as well as services for cleaning, materials organisation and logistics. The use of multiple display surfaces coupled with location awareness offers the possibility of automatically adapting information display to fit the current activity of groups. The use of activity recognition and acoustic topic spotting offers the possibility to record a log of human to human interaction, as well as to provide relevant information without disruption. The use of steerable video projectors (with integrated visual sensing) offers the possibilities of using any surface for presentation, interaction and communication.

An environment may be considered as “interactive” when it is capable of interacting with humans using tightly coupled perception and action. Simple forms of interaction may be based on observing the manipulation of physical objects, or on visual sensing of fingers, hands or arms. Richer forms of interaction require perception and understanding of human activity and context. PRIMA has developed a novel theory for situation modeling for machine understanding of human activity, based on techniques used in Cognitive Psychology [46]. PRIMA explores multiple forms of interaction, including projected interaction widgets, observation of manipulation of objects, fusion of acoustic and visual information, and systems that model interaction context in order to predict appropriate action and services by the environment.

For the design and integration of systems for perception of humans and their actions, PRIMA has developed:

- A theoretical foundation for machine understanding of human activity using situation models.
- Robust, view invariant methods for computer vision systems using local appearance.
- A software architecture model for reactive control of multimodal perceptual systems.

The experiments in project PRIMA are oriented towards developing interactive services for smart environments. Application domains include health and activity monitoring services for assisted living, smart habitat for smart energy, context aware video recording for lectures, meetings and collaborative work, context aware services for commercial environments new forms of man-machine interaction based on perception and new forms of interactive services for education, research and entertainment. Creating interactive services requires scientific progress on a number of fundamental problems, including:

- Situation models for observing and understanding human to human interaction.
- Lifelong interactive learning.
- Robust, view-invariant image description for embedded services based on computer vision.
- New forms of multimodal human-computer interaction.
- Component-based software architectures for multimodal perception and action.
- Service-oriented software architectures for smart environments.

3. Research Program

3.1. Situation Models for Context Aware Systems and Services

Context Awareness, Smart Spaces

3.1.1. Summary

Over the last few years, the PRIMA group has pioneered the use of context aware observation of human activity in order to provide non-disruptive services. In particular, we have developed a conceptual framework for observing and modeling human activity, including human-to-human interaction, in terms of situations.

Encoding activity in situation models provides a formal representation for building systems that observe and understand human activity. Such models provide scripts of activities that tell a system what actions to expect from each individual and the appropriate behavior for the system. A situation model acts as a non-linear script for interpreting the current actions of humans, and predicting the corresponding appropriate and inappropriate actions for services. This framework organizes the observation of interaction using a hierarchy of concepts: scenario, situation, role, action and entity. Situations are organized into networks, with transition probabilities, so that possible next situations may be predicted from the current situation.

Current technology allows us to handcraft real-time systems for a specific services. The current hard challenge is to create a technology to automatically learn and adapt situation models with minimal or no disruption of human activity. An important current problem for the PRIMA group is the adaptation of Machine Learning techniques for learning situation models for describing the context of human activity.

3.1.2. Detailed Description

Context Aware Systems and Services require a model for how humans think and interact with each other and their environment. Relevant theories may be found in the field of cognitive science. Since the 1980's, Philippe Johnson-Laird and his colleagues have developed an extensive theoretical framework for human mental models [47], [48]. Johnson Laird's "situation models", provide a simple and elegant framework for predicting and explaining human abilities for spatial reasoning, game playing strategies, understanding spoken narration, understanding text and literature, social interaction and controlling behavior. While these theories are primarily used to provide models of human cognitive abilities, they are easily implemented in programmable systems [37], [36].

In Johnson-Laird's Situation Models, a situation is defined as a configuration of relations over entities. Relations are formalized as N-ary predicates such as beside or above. Entities are objects, actors, or phenomena that can be reliably observed by a perceptual system. Situation models provide a structure for organizing assemblies of entities and relations into a network of situations. For cognitive scientists, such models provide a tool to explain and predict the abilities and limitations of human perception. For machine perception systems, situation models provide the foundation for assimilation, prediction and control of perception. A situation model identifies the entities and relations that are relevant to a context, allowing the perception system to focus limited computing and sensing resources. The situation model can provide default information about the identities of entities and the configuration of relations, allowing a system to continue to operate when perception systems fail or become unreliable. The network of situations provides a mechanism to predict possible changes in entities or their relations. Finally, the situation model provides an interface between perception and human centered systems and services. On the one hand, changes in situations can provide events that drive service behavior. At the same time, the situation model can provide a default description of the environment that allows human-centered services to operate asynchronously from perceptual systems.

We have developed situation models based on the notion of a script. A theatrical script provides more than dialog for actors. A script establishes abstract characters that provide actors with a space of activity for expression of emotion. It establishes a scene within which directors can layout a stage and place characters. Situation models are based on the same principle.

A script describes an activity in terms of a scene occupied by a set of actors and props. Each actor plays a role, thus defining a set of actions, including dialog, movement and emotional expressions. An audience understands the theatrical play by recognizing the roles played by characters. In a similar manner, a user service uses the situation model to understand the actions of users. However, a theatrical script is organised as a linear sequence of scenes, while human activity involves alternatives. In our approach, the situation model is not a linear sequence, but a network of possible situations, modeled as a directed graph.

Situation models are defined using roles and relations. A role is an abstract agent or object that enables an action or activity. Entities are bound to roles based on an acceptance test. This acceptance test can be seen as a form of discriminative recognition.

There is no generic algorithm capable of robustly recognizing situations from perceptual events coming from sensors. Various approaches have been explored and evaluated. Their performance is very problem and environment dependent. In order to be able to use several approaches inside the same application, it is necessary to clearly separate the specification of scenario and the implementation of the program that recognizes it, using a Model Driven Engineering approach. The transformation between a specification and its implementation must be as automatic as possible. We have explored three implementation models :

- *Synchronized petri net.* The Petri Net structure implements the temporal constraints of the initial context model (Allen operators). The synchronisation controls the Petri Net evolution based on roles and relations perception. This approach has been used for the Context Aware Video Acquisition application.
- *Fuzzy Petri Nets.* The Fuzzy Petri Net naturally expresses the smooth changes of activity states (situations) from one state to another with gradual and continuous membership function. Each fuzzy situation recognition is interpreted as a new proof of the recognition of the corresponding context.

Proofs are then combined using fuzzy integrals. This approach has been used to label videos with a set of predefined scenarios (context).

- *Hidden Markov Model*. This probabilistic implementation of the situation model integrates uncertainty values that can both refer to confidence values for events and to a less rigid representation of situations and situations transitions. This approach has been used to detect interaction groups and to determinate who is interacting with whom and thus which interaction groups are formed.

Currently situation models are constructed by hand. Our challenge is to provide a technology by which situation models may be adapted and extended by explicit and implicit interaction with the user. An important aspect of taking services to the real world is an ability to adapt and extend service behaviour to accommodate individual preferences and interaction styles. Our approach is to adapt and extend an explicit model of user activity. While such adaptation requires feedback from users, it must avoid or at least minimize disruption. We are currently exploring reinforcement learning approaches to solve this problem.

With a reinforcement learning approach, the system is rewarded and punished by user reactions to system behaviours. A simplified stereotypic interaction model assures a initial behaviour. This prototypical model is adapted to each particular user in a way that maximizes its satisfaction. To minimize distraction, we are using an indirect reinforcement learning approach, in which user actions and consequences are logged, and this log is periodically used for off-line reinforcement learning to adapt and refine the context model.

Adaptations to the context model can result in changes in system behaviour. If unexpected, such changes may be disturbing for the end users. To keep user's confidence, the learned system must be able to explain its actions. We are currently exploring methods that would allow a system to explain its model of interaction. Such explanation is made possible by explicit describing context using situation models.

The PRIMA group has refined its approach to context aware observation in the development of a process for real time production of a synchronized audio-visual stream based using multiple cameras, microphones and other information sources to observe meetings and lectures. This "context aware video acquisition system" is an automatic recording system that encompasses the roles of both the cameraman and the director. The system determines the target for each camera, and selects the most appropriate camera and microphone to record the current activity at each instant of time. Determining the most appropriate camera and microphone requires a model of activities of the actors, and an understanding of the video composition rules. The model of the activities of the actors is provided by a "situation model" as described above.

In collaboration with France Telecom, we have adapted this technology to observing social activity in domestic environments. Our goal is to demonstrate new forms of services for assisted living to provide non-intrusive access to care as well to enhance informal contact with friends and family.

3.2. Service Oriented Architectures for Intelligent Environments

Software Architecture, Service Oriented Computing, Service Composition, Service Factories, Semantic Description of Functionalities

Intelligent environments are at the confluence of multiple domains of expertise. Experimenting within intelligent environments requires combining techniques for robust, autonomous perception with methods for modeling and recognition of human activity within an inherently dynamic environment. Major software engineering and architecture challenges include accomodation of a heterogeneous of devices and software, and dynamically adapting to changes human activity as well as operating conditions.

The PRIMA project explores software architectures that allow systems to be adapt to individual user preferences. Interoperability and reuse of system components is fundamental for such systems. Adopting a shared, common Service Oriented Architecture (SOA) architecture has allowed specialists from a variety of subfields to work together to build novel forms of systems and services.

In a service oriented architecture, each hardware or software component is exposed to the others as a "service". A service exposes its functionality through a well defined interface that abstracts all the implementation details and that is usually available through the network.

The most commonly known example of a service oriented architecture are the Web Services technologies that are based on web standards such as HTTP and XML. Semantic Web Services proposes to use knowledge representation methods such as ontologies to give some semantic to services functionalities. Semantic description of services makes it possible to improve the interoperability between services designed by different persons or vendors.

Taken out of the box, most SOA implementations have some “defects” preventing their adoption. Web services, due to their name, are perceived as being only for the “web” and also as having a notable performance overhead. Other implementations such as various propositions around the Java virtual machine, often requires to use a particular programming language or are not distributed. Intelligent environments involves many specialist and a hard constraint on the programming language can be a real barrier to SOA adoption.

The PRIMA project has developed OMiSCID, a middleware for service oriented architectures that addresses the particular problematics of intelligent environments. OMiSCID has emerged as an effective tool for unifying access to functionalities provided from the lowest abstraction level components (camera image acquisition, image processing) to abstract services such as activity modeling and personal assistant. OMiSCID has facilitated cooperation by experts from within the PRIMA project as well as in projects with external partners.

3.3. Robust view-invariant Computer Vision

Local Appearance, Affine Invariance, Receptive Fields

3.3.1. Summary

A long-term grand challenge in computer vision has been to develop a descriptor for image information that can be reliably used for a wide variety of computer vision tasks. Such a descriptor must capture the information in an image in a manner that is robust to changes the relative position of the camera as well as the position, pattern and spectrum of illumination.

Members of PRIMA have a long history of innovation in this area, with important results in the area of multi-resolution pyramids, scale invariant image description, appearance based object recognition and receptive field histograms published over the last 20 years. The group has most recently developed a new approach that extends scale invariant feature points for the description of elongated objects using scale invariant ridges. PRIMA has worked with ST Microelectronics to embed its multi-resolution receptive field algorithms into low-cost mobile imaging devices for video communications and mobile computing applications.

3.3.2. Detailed Description

The visual appearance of a neighbourhood can be described by a local Taylor series [49]. The coefficients of this series constitute a feature vector that compactly represents the neighbourhood appearance for indexing and matching. The set of possible local image neighbourhoods that project to the same feature vector are referred to as the “Local Jet”. A key problem in computing the local jet is determining the scale at which to evaluate the image derivatives.

Lindeberg [51] has described scale invariant features based on profiles of Gaussian derivatives across scales. In particular, the profile of the Laplacian, evaluated over a range of scales at an image point, provides a local description that is “equi-variant” to changes in scale. Equi-variance means that the feature vector translates exactly with scale and can thus be used to track, index, match and recognize structures in the presence of changes in scale.

A receptive field is a local function defined over a region of an image [55]. We employ a set of receptive fields based on derivatives of the Gaussian functions as a basis for describing the local appearance. These functions resemble the receptive fields observed in the visual cortex of mammals. These receptive fields are applied to color images in which we have separated the chrominance and luminance components. Such functions are easily normalized to an intrinsic scale using the maximum of the Laplacian [51], and normalized in orientation using direction of the first derivatives [55].

The local maxima in x and y and scale of the product of a Laplacian operator with the image at a fixed position provides a "Natural interest point" [52]. Such natural interest points are salient points that may be robustly detected and used for matching. A problem with this approach is that the computational cost of determining intrinsic scale at each image position can potentially make real-time implementation unfeasible.

A vector of scale and orientation normalized Gaussian derivatives provides a characteristic vector for matching and indexing. The oriented Gaussian derivatives can easily be synthesized using the "steerability property" [42] of Gaussian derivatives. The problem is to determine the appropriate orientation. In earlier work by PRIMA members Colin de Verdiere [34], Schiele [55] and Hall [45], proposed normalising the local jet independently at each pixel to the direction of the first derivatives calculated at the intrinsic scale. This results for many view invariant image recognition tasks are described in the next section.

Key results in this area include

- Fast, video rate, calculation of scale and orientation for image description with normalized chromatic receptive fields [37].
- Robust visual features for face tracking [44], [43].
- Direct computation of time to collision over the entire visual field using rate of change of intrinsic scale [53].

We have achieved video rate calculation of scale and orientation normalized Gaussian receptive fields using an O(N) pyramid algorithm [37]. This algorithm has been used to propose an embedded system that provides real time detection and recognition of faces and objects in mobile computing devices.

Applications have been demonstrated for detection, tracking and recognition of faces as well detection of emotions and posture at video rates.

3.4. Perception for Social Interaction

Affective Computing, Perception for social interaction.

Current research on perception for interaction primarily focuses on recognition and communication of linguistic signals. However, most human-to-human interaction is non-verbal and highly dependent on social context. A technology for natural interaction requires abilities to perceive and assimilate non-verbal social signals, to understand and predict social situations, and to acquire and develop social interaction skills.

The overall goal of this research program is to provide the scientific and technological foundations for systems that observe and interact with people in a polite, socially appropriate manner. We address these objectives with research activities in three interrelated areas:

- Multimodal perception for social interactions.
- Learning models for context aware social interaction, and
- Context aware systems and services.

Our approach to each of these areas is to draw on models and theories from the cognitive and social sciences, human factors, and software architectures to develop new theories and models for computer vision and multi-modal interaction. Results will be developed, demonstrated and evaluated through the construction of systems and services for polite, socially aware interaction in the context of smart habitats.

3.4.1. Detailed Description

First part of our work on perception for social interaction has concentrated on measuring the physiological parameters of Valence, Arousal and Dominance using visual observation from environmental sensors as well as observation of facial expressions.

People express and feel emotions with their face. Because the face is both externally visible and the seat of emotional expression, facial expression of emotion plays a central role in social interaction between humans. Thus visual recognition of emotions from facial expressions is a core enabling technology for any effort to adapt systems for social interaction.

Constructing a technology for automatic visual recognition of emotions requires solutions to a number of hard challenges. Emotions are expressed by coordinated temporal activations of 21 different facial muscles assisted by a number of additional muscles. Activations of these muscles are visible through subtle deformations in the surface structure of the face. Unfortunately, this facial structure can be masked by facial markings, makeup, facial hair, glasses and other obstructions. The exact facial geometry, as well as the coordinated expression of muscles is unique to each individual. In additions, these deformations must be observed and measured under a large variety of illumination conditions as well as a variety of observation angles. Thus the visual recognition of emotions from facial expression remains a challenging open problem in computer vision.

Despite the difficulty of this challenge, important progress has been made in the area of automatic recognition of emotions from face expressions. The systematic cataloging of facial muscle groups as facial action units by Ekman [41] has let a number of research groups to develop libraries of techniques for recognizing the elements of the FACS coding system [33]. Unfortunately, experiments with that system have revealed that the system is very sensitive to both illumination and viewing conditions, as well as the difficulty in interpreting the resulting activation levels as emotions. In particular, this approach requires a high-resolution image with a high signal-to-noise ratio obtained under strong ambient illumination. Such restrictions are not compatible with the mobile imaging system used on tablet computers and mobile phones that are the target of this effort.

As an alternative to detecting activation of facial action units by tracking individual face muscles, we propose to measure physiological parameters that underlie emotions with a global approach. Most human emotions can be expressed as trajectories in a three dimensional space whose features are the physiological parameters of Pleasure-Displeasure, Arousal-Passivity and Dominance-Submission. These three physiological parameters can be measured in a variety of manners including on-body accelerometers, prosody, heart-rate, head movement and global face expression.

In our work, we address the recognition of social behaviours multimodal information. These are unconscious innate cognitive processes that are vital to human communication and interaction. Recognition of social behaviours enables anticipation and improves the quality of interaction between humans. Among social behaviours, we have focused on engagement, the expression of intention for interaction. During the engagement phase, many non-verbal signals are used to communicate the intention to engage to the partner [57]. These include posture, gaze, spatial information, gestures, and vocal cues.

For example, within the context of frail or elderly people at home, a companion robot must also be able to detect the engagement of humans in order to adapt their responses during interaction with humans to increase their acceptability. Classical approaches for engagement with robots use spatial information such as human position and speed, human-robot distance and the angle of arrival. Our believe is that uni-modal methods may be suitable for static display [58] and robots in wide space area [50] but not for home environments. In an apartment, relative spatial information of people and robot are not as discriminative as in an open space. Passing by the robot in a corridor should not lead to an engagement detection, and possible socially inappropriate behaviour by the robot.

In our experiments, we used a kompai robot from Robosoft [32]. As an alternative to wearable physiological sensors (such as pulse bracelet Cardiocam, etc.) we integrate multimodal features using a Kinect sensor (see figure 1). In addition of the spatial cues from the laser telemeter, one can use new multimodal features based on persons and skeletons tracking, sound localization, etc. Some of these new features are inspired from results in cognitive science domain [54].

Our multimodal approach has been confronted to a robot centered dataset for multimodal social signal processing recorded in a home-like environment [39]. The evaluation on our corpus highlights its robustness and validates use of such technique in real environment. Experimental validation shows that the use of multimodal sensors gives better results than only spatial features (50% of error reduction). Our experimentations also confirm results from [54]: relative shoulder rotation, speed and facing visage are among crucial features for engagement detection.

3.5. End User control of Smart Environments

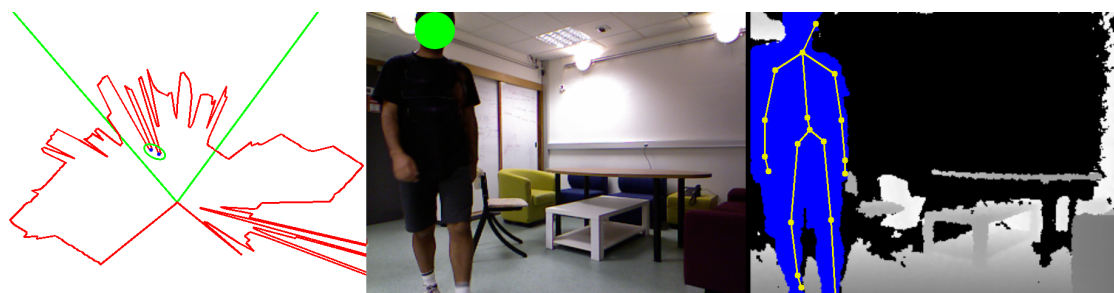


Figure 1. On the left image, one can see the telemeter range in red, the foot detection (blue spot) and the angle view from the Kinect (in green). the middle and right image represent RGB camera in depth view from the Kinect.

End users programming, smart home, smart environment

Pervasive computing promises unprecedented empowerment from the flexible and robust combination of software services with the physical world. Software researchers assimilate this promise as system autonomy where users are conveniently kept out of the loop. Their hypothesis is that services, such as music playback and calendars, are developed by service providers and pre-assembled by software designers to form new service frontends. Their scientific challenge is then to develop secure, multiscale, multi-layered, virtualized infrastructures that guarantee service front-end continuity. Although service continuity is desirable in many circumstances, end users, with this interpretation of ubiquitous computing, are doomed to behave as mere consumers, just like with conventional desktop computing.

Another interpretation of the promises of ubiquitous computing, is the empowerment of end users with tools that allow them to create and reshape their own interactive spaces. Our hypothesis is that end users are willing to shape their own interactive spaces by coupling smart artifacts, building imaginative new functionality that were not anticipated by system designers. A number of tools and techniques have been developed to support this view such as CAMP [56] or iCAP [40].

We are investigating an End-User Programming (EUP) approach to give the control back to the inhabitants. In our vision, smart homes will be incrementally equipped with sensors, actuators and services by inhabitants themselves. Our research program therefore focus on tools and languages to enable inhabitants in activities related to EUP for Smart Homes :

- Installation and maintenance of devices and services. This may imply having facilities to attribute names.
- Visualizing and controlling of the Smart Habitat.
- Programming and testing. This imply one or more programming languages and programming environment which could rely on the previous point. The programming language is especially important. Indeed, in the context of the Smart Homes, End-User Programms are most likely to be routines in the sens of [38] than procedure in the sens of traditionnal programming languages.
- Detecting and solving conflicts related to contradictory programms or goals.

4. Software and Platforms

4.1. OMiSCID Middleware for Distributed Multimodal Perception

Participants: Rémi Barraquand, Amaury Nègre, Patrick Reignier, Dominique Vaufreydaz [correspondant].

Middleware, Distributed perceptual systems

OMiSCID is lightweight middleware for dynamic integration of perceptual services in interactive environments. This middleware abstracts network communications and provides service introspection and discovery using DNS-SD (*DNS-based Service Discovery* [31]). Services can declare simplex or duplex communication channels and variables. The middleware supports the low-latency, high-bandwidth communications required in interactive perceptual applications. It is designed to allow independently developed perceptual components to be integrated to construct user services. Thus our system has been designed to be cross-language, cross-platform, and easy to learn. It provides low latency communications suitable for audio and visual perception for interactive services.

OMiSCID has been designed to be easy to learn in order to stimulate software reuse in research teams and is revealing to have a high adoption rate. To maximize this adoption and have it usable in projects involving external partners, the OMiSCID middleware has been released under an open source licence. To maximize its target audience, OMiSCID is available from a wide variety of programming languages: C++, Java, Python and Matlab. A website containing informations and documentations about OMiSCID has been set up to improve the visibility and promote the use of this middleware.

The OMiSCID graphical user interface (GUI) is an extensible graphical application that facilitates analysis and debugging of service oriented applications. The core functionality of this GUI is to list running services, their communication channels and their variables. This GUI is highly extensible and many modules (i.e. plugins) have been created by different members of the team: figure 2 shows an example of some of these modules. OMiSCID GUI is based on the Netbeans platform and thus inherits from its dynamic installation and update of modules.

4.2. Pal-Gate

Participants: Rémi Barraquand, Amaury Nègre, Dominique Vaufreydaz [correspondant].

Middleware, Distributed perceptual systems, Robotic Operating System (ROS), IPL PAL

A part of our efforts in the PAL project has been put toward developing a solution that would ease the integration of our multi-partners' software components. We refer to this solution as PALGate.

The design of PALGate results from the obvious observation that, within the PAL project, each partner must be considered as an ecosystem characterized, among other things, by 1) its software culture e.g. its curiosity and knowledge about software concepts, software architectures and design patterns, programatic languages, etc.; 2) its resources, e.g. its manpower, its possession or not of an experimental platform; 3) its competences and fields of research and expertise; 4) its habits e.g. its uses of a particular programming language, (c/c++, Java, Python) and computing platforms (OSx, Linux, Windows, Android, etc.), its adoption or not of a dedicated technology to interconnect software components (OSGi, OMiSCID, MPI, PVM, etc.); and 5) its particular needs and constraints e.g. requirement of a hard real-time system, mobility, etc.

For it to be widely accepted, PALGate is therefore designed to be ecologic and pragmatic. Ecologic in the sense that the solution does not perturb the ecology of each ecosystem¹, pragmatic in the sense that setting up this solution did not require an heavy development effort, also because it was targetted to PAL and is taking as much as possible advantage of existing solutions.

For developing PALGate we introduced a novel concept: software gate. Unlike software components/services which can be instantiated, a software gate is only a concept, it is defined as an ecologic and hermetic interface between different ecosystems. A software gate is characterized by the subset of functionalities it exposes to other gates, where the functionalities it exposes are provided by the software components/services of its belonging ecosystem. A software gate is hermetic in the sense that only a selected subset of functionalities of an ecosystem are exposed but also because it propagates only filtered information exposed by other gates into its ecosystem. The last characteristic of a software gate is that it makes explicit to other gates the communication mechanisms it uses.

¹namely, if a partner is used to Java and OSGi, deploying PALGate will not affect this in any way nor engender an heavy effort to interface it.

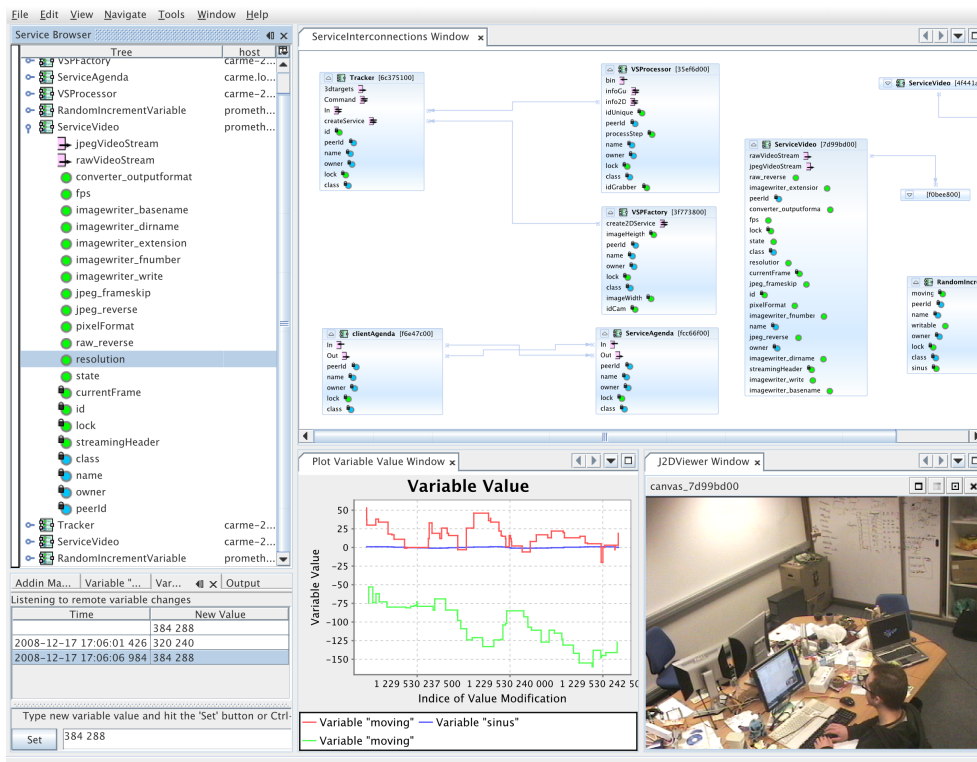


Figure 2. OMiSCID GUI showing a list of running services and some modules for service interconnections, variable plotting, live video stream display and variable control

While a software gate is only conceptual, PALGate is an implementation of a gate oriented middleware. PALGate uses ROS to support the basic communication between gates. Within PALGate, each ecosystem is associated to only one software gate. Practically, PALGate 1) is a ROS stack containing gates definition 2) is a set of conventions (e.g. stack organization, package/node/topic/service names, namespaces, etc.) 3) it provides dedicated tools to ease the integration and its usage by partners. A software gate in PALGate is a ROS package containing definition of ROS types (i.e. msgs and srvs types), but also exposed ROS communication channels (i.e. topics and RPCs).

With this architecture each partner has to provide PALGate with a package containing the definition of its gate. Then in order a) to expose functionalities out of their ecosystem and b) to propagate information into their ecosystem, each partner must create ROS nodes. These ROS nodes let each partner interface their ecosystem through ROS topics and ROS services without having to change anything about their architecture. For instance if a partner is using Java and OSGi, it can create nodes in ROS Java that will expose/register functionalities through ROS services, publish/subscribe information using ROS topics.

4.3. EmoPRAMAD

Participants: Claudine Combe, Dominique Vaufreydaz [correspondant].

Affective computing,

Within the Pramad project, we want to offer a full affective loop between the companion robot and the elderly people at home. This affective loop is necessary within the context of everyday interaction of elderly and the companion robot. A part of this loop is to make the robot express emotions in response to the emotional state of the user. To do that, we need to test our working hypothesis about the visual representation of emotions with the 3D face of robot. EmoPRAMAD is an evaluation tool designed to conduct comparative studies between human faces and the 3D faces expressing a defined set of emotions.



Figure 3. EmoPRAMAD interfaces with a human face and a 3D face from our virtual agent.

The evaluation conducted through EmoPRAMAD concerns both unimodal (facial only) and bimodal conditions (facial/sound). The emotions set is composed of 4 basic emotions (joy, fear, anger, sadness) and a neutral state. While experimenting, the software collects several parameters in order to evaluate more than correctness of the answers: time to respond, length of mouse moves, etc. Experimentation is still in progress at Inria in Grenoble, University Pierre and Marie Curie and Broca Hospital in Paris. A set of 235 participants from 14 to 88 years old was already recorded.

4.4. Detection and Tracking of Pedestrians in INRETS Intelligent Urban Spaces Platform

Participants: Claudine Combe, James Crowley [correspondant], Lukas Rummelhard.

Visual detection and tracking of pedestrians, Intelligent Urban Space

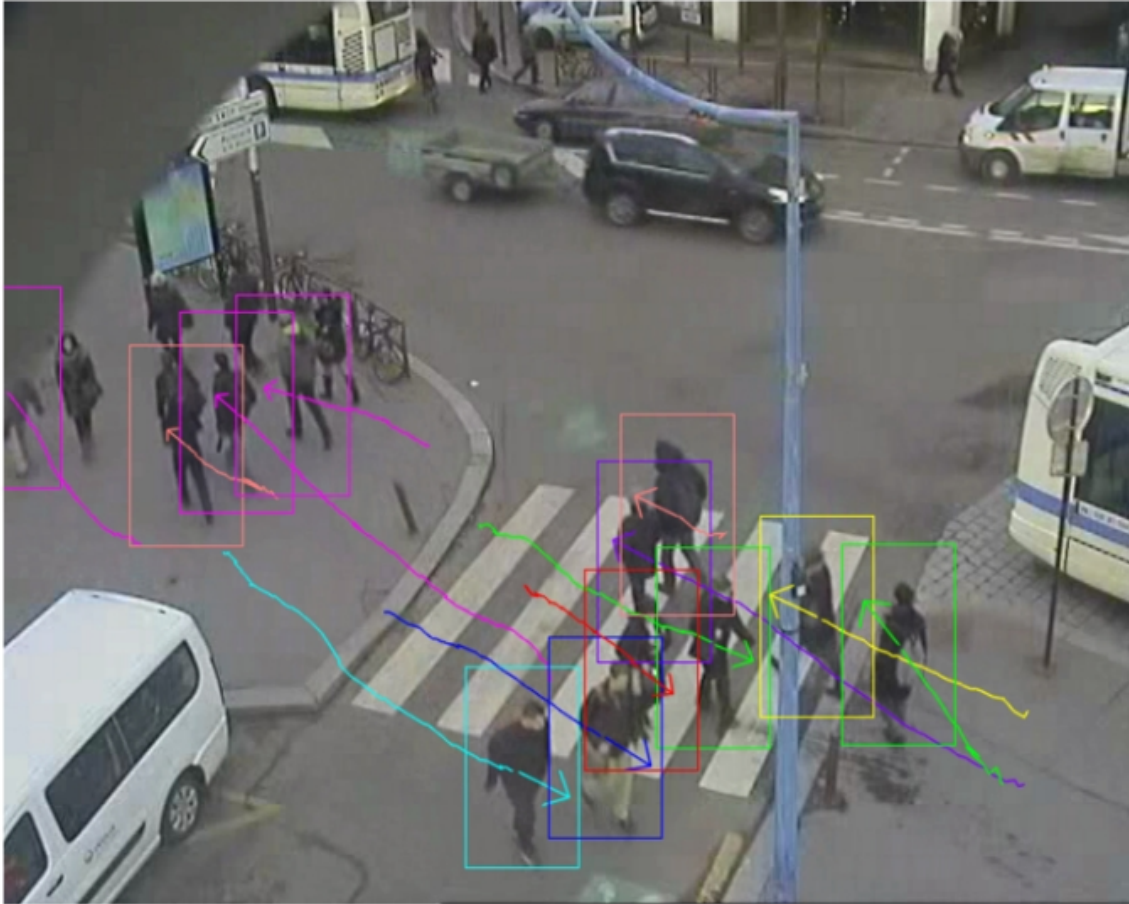


Figure 4. Cipebus: pedestrian tracking system.

The project ANR-07-TSFA-009-01 CIPEBUS ("Carrefour Intelligent - Pole d'Echange - Bus) has been proposed by INRETS-IFSTTAR, in collaboration with Inria, Citilog, Fareco, and the city of Versailles. The Objective of the CIPEBUS project is to develop an experimental platform for observing activity in a network of urban streets in order to experiment with techniques for optimizing circulation by context aware control of traffic lights.

Within CipeBus, Inria has developed a real time multi-camera computer vision system to detect and track people using a network of surveillance cameras. The CipeBus combines real time pedestrian detection with 2D and 3D Bayesian tracking to record the current position and trajectory of pedestrians in an urban environment under natural view conditions. The system extends the sliding window approach to use a half-octave Gaussian Pyramid to explore hypotheses of pedestrians at different positions and scales. A cascade classifier is used to determine the probability that a pedestrian can be found at a particular position and scale. Detected pedestrians are then tracked using a particle filter.

The resulting software system has been installed and tested at the INRETS CipeBus platform and is currently used for experiments in controlling the traffic lights to optimize the flow of pedestrians and public transportation while minimizing the delay imposed on private automobiles.

4.5. Multisensor observation of human activity for integrated energy and comfort management

Participants: Claudine Combe, James Crowley [correspondant], Lucas Nacsá, Amaury Nègre, Lukas Rummelhard.

multimodal tracking of human activity

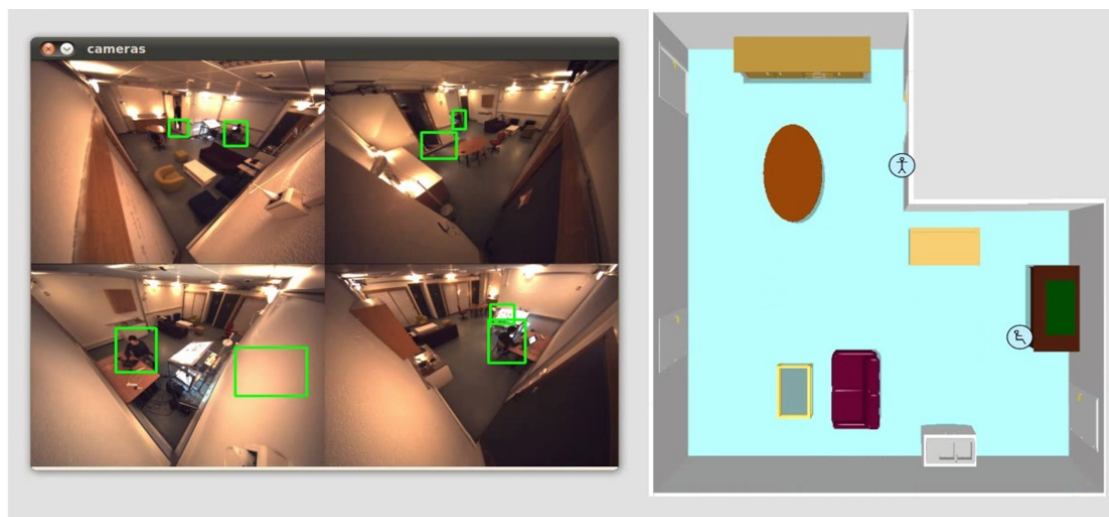


Figure 5. The 3D tracker integrates observations from multiple sensors

As part of Inria's contribution of ICTLabs Action TSES - Smart Energy Systems, we have constructed a system that integrates information from multiple environmental sensors to detect and track people in indoor environments. This system, constructed as part of activity 11831 Open SES Experience Labs for Prosumers and New Services, has been released to ICTLabs partners in June 2012. It has also been used for construction of a smart spaces testbed at Schneider Electric.

This software, named MultiSensor activity tracker, integrates information from multiple environmental sensors to keep track of the location and activity of people in a smart environment. This model is designed to be used by a home energy broker that would work in conjunction with a smart grid to manage the energy consumption of home appliances, balancing the needs of inhabitants with opportunities for savings offered by electricity rates. This database will also be used for by advisor services that will offer advice to inhabitants on the consequences to energy consumption and energy cost that could potentially result from changes to lifestyle or home energy use.

Work in this task draws from earlier results from a number of development projects at Inria. In the ANR Casper project Inria created a Bayesian tracking system for human activity using a voxel-based occupancy grid. Within the INRA ADT PAL project, Inria is creating methods for plug and play installation of visual and acoustic sensors for tracking human activity within indoor environments.

While a voxel-based Bayesian tracker has served well for a number of applications, a number of limitations have been observed. For example, under certain circumstances, the sensor data can provide contradictory or ambiguous data about the location and activities of people. Resolving such cases required the Bayesian tracker to choose between a number of competing hypotheses, potentially resulting in errors. Several members of

our group have argued that an alternative integration approach based on the use of a Particle filter would solve these problems and provide a more reliable tracking system. This task has been undertaken to evaluate this hypothesis. The system configured and optimized for detecting and tracking people within rooms using multiple calibrated cameras. The system currently uses corner mounted cartesian cameras, ceiling mounted cameras with wide angle lenses and panoramic cameras placed on tables. Cameras may be connected and disconnected while the component is running, but they must be pre-calibrated to a common room reference frame. We are currently experimenting with techniques for Bayesian estimation of camera parameters for auto-calibration. Cameras may be connected dynamically.

The original system 3DBT has been declared with the APP "Agence pour la Protection des Programmes" under the Interdeposit Digital number IDDN.FR.001.490023.000.S.P.2006.000.10000. A revised declaration for the latest version of the system is currently being prepared.

4.6. Stereo Viewfinder

Participants: Frédéric Devernavy [correspondant], Loic Lefort, Elise Mansilla, Sergi Pujades-Rocamora.

Stereoscopy, Auto-calibration, Real-time video processing, Feature matching

This software has been filed with the APP "Agence pour la Protection des Programmes" under the Interdeposit Digital number IDDN.FR.001.370083.000.S.P.2007.000.10000

4.7. Tracking Focus of Attention for Large Screen Interaction

Participants: Rémi Barraquand, Claudine Combe, James Crowley [correspondant], Varun Jain, Sergi Pujades-Rocamora, Lukas Rummelhard.

Embedded Detection and Tracking of Faces for Attention Estimation.

Large multi-touch screens may potentially provide a revolution in the way people can interact with information in public spaces. Technologies now exist to allow inexpensive interactive displays to be installed in shopping areas, subways and urban areas. Such displays can provide location aware access to information including maps and navigation guidance, information about local businesses and commercial activities. While location information is an important component of a users context, information about the age and gender of a user, as well as information about the number of users present can greatly enhance the value of such interaction for both the user and for local commerce and other activities.

The objective of this task is to leverage recent technological advances in real time face detection developed for cell phones and mobile computing to provide a low-cost real time visual sensor for observing users of large multi-touch interactive displays installed in public spaces.

People generally look at things that attract their attention. Thus it is possible to estimate the subject of attention by estimating where people look. The location of visual attention is manifested by a region of space known as the horopter where the optical axis of the two eyes intersect. However estimating the location of attention from human eyes is notoriously difficult, both because the eyes are small relative to the size of the face, and because eyes can rotate in their socket with very high accelerations. Fortunately, when a human attends to something, visual fixation tends to remain at or near that subject of attention, and the eyes are relaxed to a symmetric configuration by turning the face towards the subject of attention. Thus it is possible to estimate human attention by estimating the orientation of the human face.

We have constructed an embedded software system for detecting, tracking and estimating the orientation of human faces. This software has been designed to be embedded on mobile computing devices such as laptop computers, tablets and interactive display panels equipped with a camera that observes the user. Noting the face orientation with respect to the camera makes it possible to estimate the region of the display screen to which the user is attending.

The system uses a Bayesian Particle filter tracker operating on a Scale invariant Gaussian pyramid to provide integrated tracking and estimation of face orientation. The use of Bayesian tracking greatly improves both the reliability and the efficiency for face detection and orientation estimation. The scale invariant Gaussian pyramid provides automatic adaptation to image scale (as occurs with a change in camera optics) and makes it possible to detect and track faces over a large range of distances. Equally important the Gaussian Pyramid provides a very fast computation of a large number of image features that can be used by a variety of image analysis algorithms.

An similar software was released in 2007 using face color rather than appearance. The system *SuiviDeCiblesCouleur* located individuals in a scene for video communications. *FaceStabilisationSystem* renormalised the position and scale of images to provide a stabilised video stream. *SuiviDeCiblesCouleur* has been declared with the APP "Agence pour la Protection des Programmes" under the Interdeposit Digital number IDDN.FR.001.370003.000.S.P.2007.000.21000.

4.8. Visual Emotion Recognition for Health and Well Being.

Participants: Rémi Barraquand, Claudine Combe, James Crowley [correspondant], Varun Jain, Sergi Pujades-Rocamora, Lukas Rummelhard.

Visual Emotion Recognition

People express and feel emotions with their face. Because the face is the both externally visible and the seat of emotional expression, facial expression of emotion plays a central role in social interaction between humans. Thus visual recognition of emotions from facial expressions is a core enabling technology for any effort to adapt ICT to improve Health and Wellbeing.

Constructing a technology for automatic visual recognition of emotions requires solutions to a number of hard challenges. Emotions are expressed by coordinated temporal activations of 21 different facial muscles assisted by a number of additional muscles. Activations of these muscles are visible through subtle deformations in the surface structure of the face. Unfortunately, this facial structure can be masked by facial markings, makeup, facial hair, glasses and other obstructions. The exact facial geometry, as well as the coordinated expression of muscles is unique to each individual. In additions, these deformations must be observed and measured under a large variety of illumination conditions as well as a variety of observation angles. Thus the visual recognition of emotions from facial expression remains a challenging open problem in computer vision.

Despite the difficulty of this challenge, important progress has been made in the area of automatic recognition of emotions from face expressions. The systematic cataloging of facial muscle groups as facial action units by Ekman [41] has let a number of research groups to develop libraries of techniques for recognizing the elements of the FACS coding system [33]. Unfortunately, experiments with that system have revealed that the system is very sensitive to both illumination and viewing conditions, as well as the difficulty in interpreting the resulting activation levels as emotions. In particular, this approach requires a high-resolution image with a high signal-to-noise ratio obtained under strong ambient illumination. Such restrictions are not compatible with the mobile imaging system used on tablet computers and mobile phones that are the target of this effort.

As an alternative to detecting activation of facial action units by tracking individual face muscles, we propose to measure physiological parameters that underlie emotions with a global approach. Most human emotions can be expressed as trajectories in a three dimensional space whose features are the physiological parameters of Pleasure-Displeasure, Arousal-Passivity and Dominance-Submission. These three physiological parameters can be measured in a variety of manners including on-body accelerometers, prosody, heart-rate, head movement and global face expression.

The PRIMA Group at Inria has developed robust fast algorithms for detection and recognition of human faces suitable for use in embedded visual systems for mobile devices and telephones. The objective of the work described in this report is to employ these techniques to construct a software system for measuring the physiological parameters commonly associated with emotions that can be embedded in mobile computing devices such as cell phones and tablets.

A revised software package has recently been released to our ICTlab partners for face detection, face tracking, gender and age estimation, and orientation estimation, as part of ICTlabs Smart Spaces action line. This software has been declared with the APP "Agence pour la Protection des Programmes" under the Interdeposit Digital number IDDN.FR.001.370003.000.S.P.2007.000.21000.

A software library, named PrimaCV has been designed, debugged and tested, and released to ICTLabs partners for real time image acquisition, robust invariant multi-scale image description, highly optimized face detection, and face tracking. This software has been substantially modified so as to run on an mobile computing device using the Tegra 3 GPU.

5. New Results

5.1. Attention-Based Navigation

Participants: Adrian Bourgaud, Carlos Di Pietro, Thierry Fraichard, Rémi Paulin, Patrick Reignier, Andre Van Den Berg.

Assistant robots and robot companions are designed to share the human living space, to navigate among and interact with human beings. From the mobility point of view, roboticists have recently striven to develop navigation scheme geared towards achieving so-called "socially acceptable motions". To that end, various concepts borrowed from environmental psychology and anthropology have been used, the "personal space" concept from Proxemics being perhaps the most widely used. The purpose of our work here is to further the research in this area by taking into account other factors such as human activities, interaction configurations and intentions. An attentional model derived from cognitive psychology is used to dynamically determine the "focus of attention" of the persons involved in a given task. Depending on the task at hand, the robot uses the attention information in order to decide its future course of action so as, for instance, to attract one person's attention or, on the contrary, to minimize the disturbance caused. In 2013, a paper describing the first results obtained was presented during the Israeli Conf. on Robotics [14].

5.2. Qualitative approaches for building energy management

Participant: Patrick Reignier.

Reducing housing energy costs is a major challenge of the 21st century. In the near future, the main issue for building construction is the thermal insulation, but in the longer term, the issues are those of "renewable energy" (solar, wind, etc.) and "smart buildings". Home automation system basically consists of household appliances linked via a communication network allowing interactions for control purposes. Thanks to this network, a load management mechanism can be carried out: it is called distributed control. An optimal home energy management system is still a goal to aim for, because lots of aspects are still not completely fulfilled. Most of the energy systems respect only the energy needs, but they don't tackle the user needs or satisfaction. Energy systems also have a lack when it comes to the dynamicity of the environments (the system ability to adapt). The problem is similar for the existing HMI (Human User Interface) of those Home Automation Systems where only experts can understand the data coming from the sensors and most important, the energy plan coming from management system (How? and Why?). The goal of this study is to propose a house energy model that can be both used to predict at some level energy evolution and that can be understood by the end user. The house energy model is based on Fuzzy Cognitive Maps representing cause-effects relations. It is first designed by an expert and then automatically tuned to a particular house using machine learning approaches. Preliminary experiments have been done this year using the Predis Platform datasets.

5.3. Ikio, a sociable kiosk

Participants: Rémi Barraquand [correspondant], Jiří Pytela, Johan Girod.

In the Personal Assisted Living project we investigate the design of iKio: a sociable kiosk. A simple sketch of the iKio is illustrated in figure 6. The general idea is to enhance the interaction ability of tablet and smartphone. What motivates the choice of this type of devices is the observation that people have come to treat these gadgets as their own body appendage. As pointed out by the recent study conducted by the Pew Research Center ², people are starting to use their phones and tablets for more sensitive activities that were almost considered taboo in the past, also these devices are becoming substitute for other traditional devices like photo and video cameras.

The design of iKio is therefore influenced by this emerging form of symbiosis and aims to enhance both user-experience and human-technologies interaction. As follow, iKio does not have a fixed body per se, instead it is embodied in a tablet which can be carried along with people in their daily activities but which can also be docked into any mechanical structure that will provide it with enhanced abilities. Using such mechanical structure iKio can express emotion and interact more easily in the physical space of people. The core of iKio is specifically designed to handle and to support ostensive-inferential communication which is characteristic of human communication in contrast with the code model of communication argued to be the main reason of unadapted and autistic interaction between technologies and human. An early prototype of iKio is illustrated in figure 6. It was constructed using the Bioloid ³ construction kit.

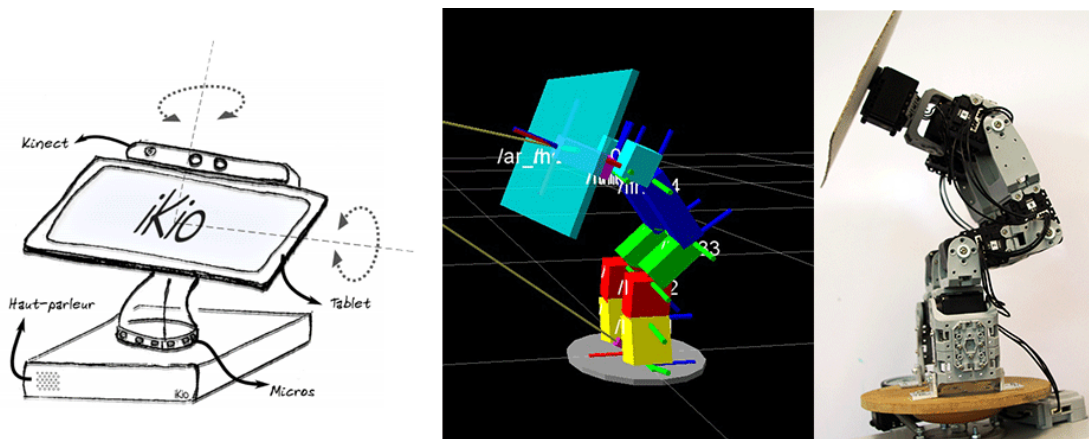


Figure 6. Preliminary sketch of the iKio together with an early prototype, both the 3d model and its realization using the Bioloid Kit

5.4. Limits and performances of embedded RGBD sensors on mobile robots for social interaction

Participants: Amaury Nègre, Dominique Vaufreydaz [correspondant].

While working on sociably acceptable companion robots, we highlighted some problems of embedding RGBD sensors on mobile robots. Performances of our algorithms can be severely decreased by intrinsic parameters of the robot: linear and angle speeds, height and angle of view of the mounted RGBD sensor, etc. We are currently conducting experiments on influence of these parameters on our perception of humans within a home-like environment. As an extra expected results, we will provide to the research community a corpus that can be used as benchmark for several tasks in mobility: 2D and 3D face detection, body and skeleton detection, fall detection and engagement detection.

²<http://pewinternet.org/>

³http://www.robotis.com/x/bioloid_en



Figure 7. Robotic platform within the home-like environment for mobile RGBD experiments.

6. Bilateral Contracts and Grants with Industry

6.1. Bilateral Contracts with Industry

Participants: Lucas Nacsa, James Crowley [correspondant].

PRIMA is currently working with Schneider Electric on algorithms image processing in a new generation of infrared visual sensors. The objective is to develop an integrated visual sensor with very low power consumption. Such systems can be used to estimate temperature in different parts of a room, as well as to provide information about human presence.

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. *EquipEx AmiQual4Home - Ambient Intelligence for Quality of Life*

Participants: Stan Borkowski, Sabine Coquillart, Joëlle Coutaz, James Crowley [correspondant], Alexandre Demeure, Thierry Fraichard, Amaury Nègre, Patrick Reignier, Dominique Vaufreydaz, Nicolas Bonnefond, Rémi Pincet, Mayeul de Werbier d Antigneul, Rémi Barraquand, David Lombard.

Ambient Intelligence, Equipment d'Excellence, Investissement d'Avenir

The AmiQual4Home Innovation Factory is an open research facility for innovation and experimentation with human-centered services based on the use of large-scale deployment of interconnected digital devices capable of perception, action, interaction and communication. The Innovation Factory is composed of a collection of workshops for rapid creation of prototypes, surrounded by a collection of living labs and supported by a industrial innovation and transfer service. Creation of the Innovation Factory has been made possible by a 2.140 Million Euro grant from French National programme "Investissement d'avenir", together with substantial contributions of resources by Grenoble INP, Univ Joseph Fourier, UPMF, CNRS, Schneider Electric and the Commune of Montbonnot. The objective is to provide the academic and industrial communities with an open platform to enable research on design, integration and evaluation of systems and services for smart habitats.

The AmiQual4Home Innovation Factory is a unique combination of three different innovation instruments: (1) Workshops for rapid prototyping of devices that embed perception, action, interaction and communication in ordinary objects based on the MIT FabLab model, (2) Facilities for real-world test and evaluation of devices and services organised as open Living Labs, (3) Resources for assisting students, researchers, entrepreneurs and industrial partners in creating new economic activities. The proposed research facility will enable scientific research on these problems while also enabling design and evaluation of new forms of products and services with local industry.

The core of the AmiQual4Home Innovation Factory is a Creativity Lab composed of a collection of five workshops for the rapid prototyping of devices that integrate perception, action, interaction and communications into ordinary objects. The Creativity Lab is surrounded by a collection of six Living Labs for experimentation and evaluation in real world conditions. The combination of fabrication facilities and living labs will enable students, researchers, engineers, and entrepreneurs to experiment in co-creation and evaluation. The AmiQual4Home Innovation Factory will also include an innovation and transfer service to enable students, researchers and local entrepreneurs to create and grow new commercial activities based on the confluence of digital technologies with ordinary objects. The AmiQual4Home Innovation Factory will also provide an infrastructure for participation in education, innovation and research activities of the European Institute of Technology (EIT) KIC ICTLabs.

The AmiQual4Home Innovation Factory will enable a unique new form of coordinated ICT-SHS research that is not currently possible in France, by bringing together expertise from ICT and SHS to better understand human and social behaviour and to develop and evaluate novel systems and services for societal challenges. The confrontation of solutions from these different disciplines in a set of application domains (energy, comfort, cost of living, mobility, well-being) is expected to lead to the emergence of a common, generic foundation for Ambient Intelligence that can then be applied to other domains and locations. The initial multidisciplinary consortium will progressively develop interdisciplinary expertise with new concepts, theories, tools and methods for Ambient Intelligence.

The potential impact of such a technology, commonly referred to as "Ambient Intelligence", has been documented by the working groups of the French Ministry of Research (MESR) [35] as well as the SNRI (Stratégie Nationale de la Recherche et de l'Innovation).

In 2013 our efforts were focused on specifying the requirements for major components of the project, and on finalising contractual issues with ANR. We defined the layout and arrangement of the Creativity Lab workshops, we started the specification of the instrumentation needed for the Living Labs, and developed a first version of a set of easy-deployable wireless sensors for infield data acquisition, that we call the Rapid Deployment Minikit. A set of CNC machines was purchased, including a Fused Filament Fabrication 3D printer, a CO2 Laser cutter and engraver, and a CNC mill.

Following the kickoff meeting of the project held in October 2013, we received positive feedback and interest from local industry and research institutions, and several national project proposals submitted in 2013 identified AmiQual4Home as an important resource.

7.1.2. FUI PRAMAD

Participants: Claudine Combe, Lucas Nacsá, Maxime Portaz, Amaury Nègre, Dominique Vaufreydaz [correspondant].

Pramad is a collaborative project about *Plateforme Robotique d'Assistance et de Maintien à Domicile*. There are seven partners:

- R&D/industry: Orange Labs (project leader) and Covéa Tech (insurance company),
- Small companies: Interaction games (game designer, note that Wizardbox, the original partner was bought by Interaction games) and Robosoft (robot).
- Academic labs: Inria/PRIMA, ISIR (Paris VI) and Hôpital Broca (Paris).

The objectives of this project are to design and evaluate robot companion technologies to maintain frail people at home. Working with its partners, PRIMA research topics are:

- social interaction,
- robotic assistance,
- serious game for frailty evaluation and cognitive stimulation.

7.1.3. Inria Project-Teams PAL

Participants: Rémi Barraquand, Thierry Fraichard, Patrick Reignier, Amaury Nègre, Dominique Vaufreydaz [correspondant].

The 12 Inria Project-Teams (IPT) participating in a Large-scale initiative action Personally Assisted Living (PAL <http://pal.inria.fr>) propose to work together to develop technologies and services to improve the autonomy and quality of life for elderly and fragile persons. The goal of this program is to unite these groups around an experimental infrastructure, designed to enable collaborative experimentations.

PAL is organized around 12 IPT:

Demar, E-Motion, Flowers, Hephaistos, Lagadic, Lagadic-Sophia, Maia, Madynes, Phoenix, Prima, Stars and Reves.

The role of PRIMA within this project is to develop new algorithms mainly along two research axes:

- assessing frailty degree of the elderly,
- social interaction.

7.2. European Initiatives

7.2.1. Collaborations in European Programs, except FP7

7.2.1.1. CATRENE AppsGate

Participants: Jean-René Courtois, Rémy Dautriche, Alexandre Demeure [correspondant], Cédric Gérard, Camille Lenoir, Kouzma Petoukhov, Patrick Reignier.

AppsGate is a project about End User Development in the context of SmartHomes. There are seven partners:

- R&D/industry:
 - ST Microelectronics, NXP, PACE, Technicolor, ARD, Ripple Motion, 4MOD, HIERIA, VSN+UAB, SoftKinetic, Optrima, Vsonix, Evalan, Vestel, Turkcell, Immotronics.
- Academic labs:
 - Inria/PRIMA, Institut télécom.

The objectives of this project are to design and evaluate a new generation of set-top box, PRIMA is involved in designing End User Development tools dedicated for the Smart Home.

7.3. International Initiatives

7.3.1. Inria International Partners

7.3.1.1. Declared Inria International Partners

The Prima team participates in the project “Visually impaired people assistance using multimodal technologies”. The project leader is the Mica laboratory of Hanoi University of Science and Technology (HUST), the project is financed for three years, starting in July 2012, by the Flemish Interuniversity Council (VLIR UOS <http://www.vliruos.be/en>). The other partners are Danang University, Ghent University, and Imep-Lahc (Grenoble Inp). The overall objective of the project is to provide visually impaired children (in the Nguyen Dinh Chieu School in Hanoi) with helpful devices. The contact person in the Prima team is Augustin Lux. Prima contributed to the design and testing of a system for Visual Object Recognition.

Since the PERSPOS project (BQR Grenoble INP 2008-2009), the MICA center (UMI 2954 CNRS) and PRIMA has a long time collaboration on the concept of "large-scale" perceptive space. This space is an intelligent environment which will be deployed on a large surface containing several buildings (as a university campus for example). The user is wearing one or many mobile intelligent wireless devices (smartphone or wearable computer). By combining the concepts of large-scale perceptive environments and mobile computing, we can create intelligent spaces to propose services adapted to individuals and their activities, manage energy of building, etc. Our collaboration is focusing on user identification and localization within such a smart space. Tracking people in smart environments remains a challenging fundamental problem when tackling multiple users localization. Whether it is at the scale of a campus, of a building or more simply of a room, we can dynamically combine several localization levels (and several technologies) to allow a more accurate and reliable users localization system. In September 2013, a new co-supervised Ph.D. Thesis started on multiple users localization in large-scale perceptive spaces.

7.4. International Research Visitors

7.4.1. Internships

Participant: Carlos Di Pietro.

Subject: Design of a Robot Companion

Date: from March 2013 until August 2013

Institution: University of Buenos Aires (Argentina)

Participant: Muhamamd Amine Bouguerra.

Subject: Viability and Guaranteed Motion Safety

Date: from Sep. 2013 until Oct. 2013

Institution: University of Annaba (DZ)

Participant: Marceau Thalgott.

Subject: Bibliographical study of Brain Like Artificial Intelligence, Mini-Kit prototype development for a smart home.

Date: from February 2013 until August 2013

Institution: ENSIMAG

Participant: Adrien Czerny.

Subject: Software environment for life long learning and debugging of a cortical learning algorithm.

Date: from February 2013 until August 2013

Institution: ENSIMAG

Participant: Luiza Cicone.

Subject: Tools to support creative and design processes of interactive systems

Date: from March 2013 until August 2013

Institution: ENSIMAG

Participant: Simon Chalumeau.

Subject: Pico-Projector based Interaction

Date: from February 2013 until August 2013

Institution: Grenoble INP, UJF Grenoble

Participant: Maxime Portaz.

Subject: Supervised and unsupervised learning for intention recognition

Date: from March 2013 until August 2013

Institution: Université de Grenoble (Grenoble, France)

Participant: Martin Poirrier.

Subject: Robotics and Multimodal Sensor Fusion for detecting Human Social interaction

Date: from January 2013 until June 2013

Institution: Supinfo (Grenoble, France)

7.4.2. Visits to International Teams

Dominique Vaufreydaz, June 2013, MICA research center of Hanoi University of Science and Technology (HUST), in Hanoi Vietnam.

8. Dissemination

8.1. Scientific Animation

8.1.1. Sabine Coquillart

8.1.1.1. Animation of the Scientific Community

- Sabine Coquillart has served as a member of the Conference Committee of IEEE VR 2013 - IEEE Virtual Reality, Orlando, FL, USA, March 2013.
- Sabine Coquillart has co-chaired the Dagstuhl seminar on "Virtual realities", June 2013.
- Sabine Coquillart is elected member of the EUROGRAPHICS Executive Committee.
- Sabine Coquillart is member of the EUROGRAPHICS Working Group and Workshop board.

8.1.1.2. Participation on Conference Program Committees

- Sabine Coquillart has served as International Program Committee co-chair for IEEE VR 2013 - IEEE Virtual Reality, Orlando, FL, USA, March 2013.
- Sabine Coquillart has served as Program co-chair for GRAPP - the International Conference on Computer Graphics Theory and Applications, Barcelona, Spain, Feb. 2013.
- Sabine Coquillart has served as area co-chair (Virtual reality) for ISVC 2013 - the 9th International Symposium on Visual Computing, Rethymnon, Crete, Greece, July 2013.

Sabine Coquillart has served as a member of the program committee for the following conferences:

- GRAPP'2013 - International Conference on Computer Graphics Theory and Applications - Barcelona Spain, Feb. 2013.
- CASA 2013 - International Conference on Computer Animation and Social Agents - Istanbul, Turkey, May 2013.
- CGI 2013 - Computer Graphics International ,Hannover, Germany, June 2013.
- CGVCVIP 2013 - IADIS Computer Graphics, Visualization, Computer Vision and Image Processing - Prague, Czech Republic, July 2013.
- CVRB 2013 - International Conference on Virtual Reality and Broadcasting, Dusseldorf, Germany, 2013.
- DigitalHeritage 2013, Marseille, France, Oct-Nov 2013.
- GRAPHICON'2013 - International Conference on Computer Graphics and Vision - Vladivostok, Russia, October 2013.
- ICAT 2013, the 23rd International Conference on Artificial Reality and Telexistence, Tokyo, Japan, Dec 2013.
- ICVRV 2013 - International Conference on Virtual Reality and Visualization 2013, Xi'an, China, September 2013.
- IEEE 3DUI 2013 - IEEE 3D User Interfaces - Orlando, FL, USA, March 2013.
- ISMAR 2012 - IEEE International Symposium on Mixed and Augmented Reality - Adelaide, Australia, Oct. 2013 (reviewer).

- JVRC 2013 - Joint Virtual Reality Conference on Virtual Reality of EGVE - EuroVR, Orsay, France, Dec. 2013.
- VRIC 2013 - Virtual Reality International Conference, Laval, 2013.
- SUI 2013 - ACM Symposium on Spatial User Interaction, Los Angeles, CA, USA, Jul. 2013.
- SVR 2013 - Symposium on Virtual and Augmented Reality - Brazil , May 2013.
- VisGra 2013 - International Workshop on Computer Vision and Computer Graphics - Sevilla Spain, Jan. - Feb. 2013.
- VRST 2013 - 19th ACM Symposium on Virtual Reality Software and Technology, Nanyang, Singapore, Oct. 2013.
- WSCG 2013 - International Conferences in Central Europe on Computer Graphics, Visualization and Computer Vision - Prague, Czech Republic, 2013.

8.1.1.3. *Participation on Advisory panels*

- Sabine Coquillart is serving as member of the steering committee for the ICAT conference - International Conference on Artificial Reality and Telexistence.
- Sabine Coquillart is chairing the steering committee for the EGVE Working Group - EUROGRAPHICS Working group on Virtual Environments.
- Sabine Coquillart was a member of the FET pool of experts for European Commission funding under the framework of FET Open.
- Sabine Coquillart has reviewed proposal for ANR - the "Agence National de la Recherche".

8.1.1.4. *Participation on Journal Editorial Boards*

- S. Coquillart, J.J. LaViola Jr., Z. Pan, D. Schmalstieg (Guest Editors), IEEE Transactions on Visualization and Computer Graphics, vol. 19 n. 4, 2013.
- Sabine Coquillart is a member of the Editorial Board of the Journal of Virtual Reality and Broadcasting.
- Sabine Coquillart is co-Guest Editor for some papers of an issue of Presence: Teleoperators & Virtual Environments Journal, 2013.
- Sabine Coquillart is a member of the Editorial board (computer Sciences) of the Scientific World Journal.
- Sabine Coquillart is a member of the Editorial Board of the Advances in Human-Computer Interaction Journal.

8.1.1.5. *Invited Presentations by Sabine Coquillart*

- "Réalité Virtuelle et Réalité Augmentée, une introduction centrée utilisateur", ENS Cachan, Paris, Sept. 2013.

8.1.2. **James L. Crowley**

James L. Crowley has served as a Program Chair for PETS 2013. He was a member of the technical program committee for Ubicomp 2013. He has reviewed papers for CVPR, ICCV, ICRA, ICMI, ICVS, and IE. He has served as member of the selection committee for the Institut Universitaire de France (IUF) Junior. He served as expert for the European Commission ICT program. He has served as member of EDF competition on Smart energy.

8.1.3. **Thierry Fraichard**

Thierry Fraichard has served as an Associated Editor for IEEE/RSJ Int. Conf/ on Intelligent Robots and Systems 2013 (IROS) and IEEE Int. Conf. on Robotics and Automation (ICRA). He has served as a Program Committee member for the European Conf. on Mobile Robots 2013 (ECMR). He has reviewed papers for different conferences and journal in his domain (IV, JFR, RAS, IEEE TRO, IJRR, EuroGraphics) and has reviewed projects in the European FET Xtrack program.

8.1.4. Patrick Reignier

Patrick Reignier has served as a Program Committee member for the following conferences:

- INTERACT 2013, 2 - 6 September 2013, Cape Town, South Africa
- IUI 2013, poster session, March 2013, Santa Monica, USA
- Smart Object Workshop of IUI 2013, March 2013, Santa Monica, USA

He also reviewed papers for the main track of IUI 2013. He has been re-elected for 3 years at the board of the Association Française pour l'Intelligence Artificielle (AFIA). He has co-organized the joint scientific day between the HMI and the Artificial Intelligence Associations.

8.1.5. Dominique Vaufreydaz

Dominique Vaufreydaz has served as reviewer and Program Committee member for the following conferences:

- the Eighth IEEE International Workshop on Multimedia Technologies for E-Learning (MTEL) in conjunction with the IEEE International Symposium on Multimedia 2013 (ISM2013), December 2013, Anaheim, CA, USA.
- the 2nd Workshop on Assistance and Service robotics in a human environment at IEEE International Conference on Intelligent Robots and Systems (IROS2013), November 2013, Tokyo, Japan.
- the Seventh International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies (UBICOMM 2013), October 2013, Porto, Portugal.
- the International Workshop on Wireless Communications and User-centered Services in Pervasive Environments (WUSPE2013), September 2013, Hanoi, Vietnam.
- the 1st Workshop on Affective Social Speech Signals (WASSS) in conjunction with Interspeech 2013, August 2013, Grenoble/Lyon, France.

He has reviewed articles for:

- the IEEE Robot and Human Interaction Communication (Ro-Man 2013), August 2013, Gyeonggy, South Korea.
- the IEEE International Conference on Robotics and Automation (ICRA 2013), May 2013, Karlsruhe, Germany.

He was in the Organization Committee of the 1st Workshop on Affective Social Speech Signals (WASSS) (in conjunction with Interspeech 2013), in August 2013, Grenoble/Lyon, France. He co-organized the Keynotes Speeches of the LIG Laboratory <http://www.liglab.fr/spip.php?article884>. He served as expert for the TecSan 2013 call for project from ANR. He was elected as representative of the researchers at the Inria Grenoble Research Center Committee.

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

8.2.1.1. James Crowley

- Computer Vision, Course 24h EqTD, M2 year, Master of Science in Informatics at Grenoble,
- Intelligent Sisetms, Cours 54h EqTD, ENSIMAG

James Crowley is Director of the Master of Science in Informatics at Grenoble.

8.2.1.2. Sabine Coquillart

- Sabine Coquillart teaches a course on “Virtual Reality and 3D User Interfaces” for the GVR Master 2R, 2013-2014.
- Sabine Coquillart teaches a one day course on “3D User Interfaces and Augmented Reality” for the “Numerical Modeling and Virtual Reality” Master 2 in Laval, 2013-2014.

8.2.1.3. Thierry Fraichard

Licence: Thierry Fraichard, Introduction à la robotique, 19h eqTD, L3 INFO, Univ. of Grenoble, France.

Licence: Thierry Fraichard, Algorithmique, 36h eqTD, M1, ENSIMAG/Grenoble INP, France.

Master: Thierry Fraichard, Introduction to Perception and Robotics, 23h eqTD, M1 MOSIG, Univ. of Grenoble, France.

Master: Thierry Fraichard, Advanced Motion Planning (invited course), 9 heqTD, Centre de Développement des Technologies Avancées, Algiers (DZ), Jan. 2013.

8.2.1.4. Patrick Reignier

Master: Patrick Reignier, Projet Génie Logiciel, 55h eqTD, M1, ENSIMAG/Grenoble INP, France.

Master : Patrick Reignier, Développement d’applications communicantes, 18h eqTD, M2, ENSIMAG/Grenoble - INP, France

Master : Patrick Reignier, Introduction aux applications réparties, 18h eqTD, M2, ENSIMAG/Grenoble - INP, France

Master: Patrick Reignier, Programmation Internet, 18h eqTD, M1, ENSIMAG/Grenoble INP, France

Licence: Patrick Reignier, Algorithmique, 70h eq TD, L3, ENSIMAG/Grenoble INP, France

Licence: Patrick Reignier, Projet C, 20h eqTD, L3, ENSIMAG/Grenoble INP, France.

Patrick Reignier is supervising the industrial part of the “formation en apprentissage” of the ENSIMAG engineering school.

8.2.2. Supervision

8.2.2.1. PhD defended in 2013

Antoine Méler, BetaSAC et OABSAC, Deux Nouveaux Echantillonnages Conditionnels pour RANSAC, Thesis defended January 2013, Thesis Director James Crowley.

Marion Décrouez, Modélisation et Localisation Visuelle dans les Environnement Dynamiques, Thesis defended May 2013, Thesis Directed by Frédéric Devernay and James Crowley.

8.2.2.2. PhD in progress

Evanthia Mavridou, Visual Invariants for Detection and Recognition, Université de Grenoble, expected fall 2014, James Crowley (Professor)

Varun Jain, Perception of Human Emotions, Université de Grenoble, expected fall 2014, James Crowley (Professor)

Sergi Pujades-Rocamora, Modèles de caméras et algorithmes pour la création de contenu video 3D, expected fall 2015, Rémi Ronfard (HDR) et Frédéric Devernay

Julian Quiroga, Visual Perception of Gestures, Université de Grenoble, expected fall 2014, James Crowley (Professor) and Frédéric Devernay

Dimitri Masson, Modèles et outils pour favoriser la créativité dans les premières phases de conception d’IHM, Université de Grenoble, expected fall 2014, Gaëlle Calvary (Professor) and Alexandre Demeure

Étienne Balit, Multimodalité et interaction sociale, Université de Grenoble, expected Fall 2016, Patrick Reignier (Professor), Dominique Vaufraydaz.

Viet Cuong Ta, Multiple Users localization in public large-scale space, Université de Grenoble, expected Fall 2016, Eric Castelli (HDR, Mica laboratory Hanoi, Vietnam), Dominique Vaufreydaz, Rémi Paulin, Human-Robot Motion, Univ. of Grenoble, expected Fall 2016, Thierry Fraichard (HDR).

8.2.3. *Juries*

- Sabine Coquillart (examiner), HDR, Mehdi Ammi, Univ Paris-Sud - LIMSI, Nov. 2013
- Sabine Coquillart (reviewer), PhD, Florimond Guéniat, Univ Paris-Sud - LIMSI, Dec. 2013
- James Crowley (reviewer), HDR, Jean-Pierre Nikolovski, Univ Paris - UPMC, Dec. 2013
- James Crowley (reviewer), PhD, Alberto Calatroni, ETH Zurich, Sept. 2013
- James Crowley (jury president), PhD, Alfonso Garcia-Frey, Université de Grenoble, July 2013
- James Crowley (jury president), PhD, Jorgé Rios Martinez, Université de Grenoble, Jan. 2013
- Thierry Fraichard (reviewer), PhD, Adam Houenou, Univ. Tech. de Compiègne, Dec. 2013.
- Thierry Fraichard (jury president), PhD, Asma Azim, LIG, December 2013.
- Patrick Reignier (examiner), PhD, Pedro Chahuara, LIG, March 2013.
- Patrick Reignier (examiner), PhD, Benoît Vettier, LIG, Sep. 2013.
- Patrick Reignier (examiner), PhD, Benjamin Cogrel, Université Paris Est, Nov. 2013.
- Patrick Reignier (examiner), HDR, Julie Dugdale, LIG, Dec. 2013.
- Patrick Reignier (reviewer), DRI (Diplome de Recherche et d'Innovation), Safietou Thior, LIG, May 2013.

8.3. Invited Presentations

8.3.1. *James Crowley*

- James Crowley, Socially Intelligent Human Computer Interaction, Journée Interaction Homme-Machine et Intelligence Artificielle, Paris, 28 March 2013.
- James Crowley, Table ronde “Robotique intelligente et compétitivité des PME”, InnoRobot, Lyon, 19 Mars 2013.

8.3.2. *Thierry Fraichard*

- Will the driver seat ever be empty?, Technion, Haifa (IL), April 2013.
- Will the driver seat ever be empty?, Tel Aviv University (IL), June 2013.
- Will the driver seat ever be empty?, Ariel University (IL), June 2013.
- Will the driver seat ever be empty?, Bar Ilan University, Ramat Gan (IL), Oct. 2013.

8.3.3. *Dominique Vaufreydaz*

- Multimodal perception, activity recognition and companion robots, MICA laboratory, Hanoi (Vietnam), June 2013.
- Invited speaker at “L’Homme 2.0 et son environnement – Entre rejet et fascination”, an inter-professional meeting (entrepreneurs, researchers, artists, associative and institutional actors), Université de Lyon, December 2013.

8.4. Popularization

- Thierry Fraichard gave three lectures on Robotics to highschool students and teachers in the scope of the “Informatique au lycée” initiative, April and May 2013.
- Dominique Vaufreydaz gave two lectures on perception and companion robot to highschool students and teachers in the scope of the “Informatique au lycée” initiative, April and May 2013.
- Dominique Vaufreydaz gave seminars entitled “Perception, reconnaissance d’activités et robots compagnons.”, Fêtes de la Science, at Inria Grenoble, Monbonnot, October 2013.
- The first version of the AppsGate integration platform was demonstrated to the public as part of the Experimenta Fair ⁴ in Grenoble, from 10 to 13 of October 2013.

⁴<http://www.echosciences-grenoble.fr/sites/experimenta>

9. Bibliography

Major publications by the team in recent years

- [1] O. BRDICZKA, J. CROWLEY, P. REIGNIER. *Learning Situation Models in a Smart Home*, in "IEEE Transactions on System, Man and Cybernetics, part B", 2009, vol. 39, n^o 1, <http://hal.inria.fr/hal-00665319/en>
- [2] O. BRDICZKA, M. LANGET, J. MAISONNASSE, J. L. CROWLEY. *Detecting human behavior models from multimodal observation in a smart home*, in "Automation Science and Engineering, IEEE Transactions on", 2009, vol. 6, n^o 4, pp. 588–597
- [3] O. BRDICZKA, J. MAISONNASSE, P. REIGNIER, J. CROWLEY. *Detecting Small Group Activities from Multimodal Observations*, in "International Journal of Applied Intelligence", 2009, vol. 30, n^o 1, pp. 47–57, http://www-prima.imag.fr/jlc/papers/articleAI_brdiczka12Mars07.pdf
- [4] J. COUTAZ, J. CROWLEY, S. DOBSON, D. GARLAN. *Context is key*, in "Communications of the ACM", March 2005, vol. 48, n^o 3, pp. 49–53
- [5] J. CROWLEY, O. BRDICZKA, P. REIGNIER. *Learning Situation Models for Understanding Activity*, in "The 5th International Conference on Development and Learning 2006 (ICDL06)", Bloomington, IL, USA, June 2006
- [6] J. CROWLEY, J. COUTAZ, F. BÉRARD. *Things that See: Machine Perception for Human Computer Interaction*, in "Communications of the A.C.M.", March 2000, vol. 43, n^o 3, pp. 54–64
- [7] J. CROWLEY, J. COUTAZ, G. REY, P. REIGNIER. *Using Context to Structure Perceptual Processes for Observing Activity*, in "UBICOMP", Sweden, September 2002
- [8] N. GOURIER, D. HALL, J. L. CROWLEY. *Facial features detection robust to pose, illumination and identity*, in "Systems, Man and Cybernetics, 2004 IEEE International Conference on", IEEE, 2004, vol. 1, pp. 617–622
- [9] N. GOURIER, J. MAISONNASSE, D. HALL, J. L. CROWLEY. *Head pose estimation on low resolution images*, in "Multimodal Technologies for Perception of Humans", Springer Berlin Heidelberg, 2007, pp. 270–280
- [10] D. HALL. *Automatic parameter regulation of perceptual systems*, in "Image and Vision Computing", August 2006, vol. 24, n^o 8, pp. 870–881, <http://dx.doi.org/10.1016/j.imavis.2006.02.011>

Publications of the year

Doctoral Dissertations and Habilitation Theses

- [11] M. DECROUEZ. , *Modélisation des environnements dynamiques pour la localisation*, Université de Grenoble, May 2013, <http://hal.inria.fr/tel-00936114>
- [12] A. MÉLER. , *BetaSAC et OABSAC, deux nouveaux échantillonnages conditionnels pour RANSAC*, Université de Grenoble, January 2013, <http://hal.inria.fr/tel-00936650>

Articles in International Peer-Reviewed Journals

- [13] J. QUIROGA, F. DEVERNAY, J. L. CROWLEY. *Local scene flow by tracking in intensity and depth*, in "Journal of Visual Communication and Image Representation", January 2014, vol. 25, n^o 1, pp. 98-107 [DOI : 10.1016/J.JVCIR.2013.03.018], <http://hal.inria.fr/hal-00817011>

International Conferences with Proceedings

- [14] T. FRAICHARD, P. REIGNIER. *Attention-Based Navigation in Human-Populated Environments*, in "Israeli Conference on Robotics", Tel Aviv, Israel, November 2013, <http://hal.inria.fr/hal-00861840>
- [15] V. JAIN, J. CROWLEY. *Smile Detection Using Multi-scale Gaussian Derivatives*, in "12th WSEAS International Conference on Signal Processing, Robotics and Automation", Cambridge, United Kingdom, February 2013, <http://hal.inria.fr/hal-00807362>
- [16] V. JAIN, J. L. CROWLEY. *Head Pose Estimation Using Multi-scale Gaussian Derivatives*, in "18th Scandinavian Conference on Image Analysis", Espoo, Finland, June 2013 [DOI : 10.1007/978-3-642-38886-6_31], <http://hal.inria.fr/hal-00839527>
- [17] A. NAJJAR, P. REIGNIER. *Constructivist Ambient Intelligent Agent for Smart Environments*, in "PerCom - IEEE International Conference on Pervasive Computing and Communications", San Diego, United States, March 2013, <http://hal.inria.fr/hal-00806381>
- [18] J. QUIROGA, F. DEVERNAY, J. L. CROWLEY. *Local/Global Scene Flow Estimation*, in "ICIP - IEEE International Conference on Image Processing", Melbourne, Australia, IEEE, September 2013, <http://hal.inria.fr/hal-00829515>

Conferences without Proceedings

- [19] S. PUJADES, F. DEVERNAY. *Détection de différence de mise au point lors des prises de vues stéréoscopiques*, in "Orasis, Congrès des jeunes chercheurs en vision par ordinateur", Cluny, France, June 2013, <http://hal.inria.fr/hal-00829397>
- [20] S. PUJADES, F. DEVERNAY. *Utilisation des longues focales lors des prises de vues stéréoscopiques*, in "Orasis, Congrès des jeunes chercheurs en vision par ordinateur", Cluny, France, June 2013, <http://hal.inria.fr/hal-00829395>

Scientific Books (or Scientific Book chapters)

- [21] J. BRAZ, C. ANDUJAR, S. COQUILLART. , *GRAPP & IVAPP 2013 : Proceedings of the International Conference on Computer Graphics Theory and Applications and International Conference on Information Visualization Theory and Applications*, Scitepress, February 2013, 200 p. , <http://www.scitepress.org/DigitalLibrary/User/ListPapers.aspx>, <http://hal.inria.fr/hal-00932665>
- [22] G. BREBIS, R. BOYLE, D. KORACIN, B. PARVIN, B. LI, F. PORIKLI, V. ZORDAN, J. KLOSOWSKI, S. COQUILLART, X. LUO, M. CHEN, D. GOTZ. , *Advances in Visual Computing : 9th International Symposium, ISVC 2013, Proceedings, Part I*, Lecture Notes in Computer Science, Springer 2013, July 2013, 586 p. , <http://www.springer.com/computer/image+processing/book/978-3-642-41913-3>, <http://hal.inria.fr/hal-00932480>
- [23] G. BREBIS, R. BOYLE, D. KORACIN, B. PARVIN, B. LI, F. PORIKLI, V. ZORDAN, J. KLOSOWSKI, S. COQUILLART, X. LUO, M. CHEN, D. GOTZ. , *Advances in Visual Computing : 9th International Symposium, ISVC 2013, Proceedings, Part II. In Lecture Notes in Computer Science, Springer 2013*, Lecture Notes in

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- [24] G. BRUNETT, S. COQUILLART, R. VAN LIERE, G. WELCH. , *Virtual Realities (Dagstuhl Seminar 13241)*, Dagstuhl Research Online Publication Server, June 2013, 66 p. , http://drops.dagstuhl.de/opus/volltexte/2013/4257/pdf/dagrep_v003_i006_p038_s13241.pdf, <http://hal.inria.fr/hal-00932678>
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- [26] F. DEVERNAY, Y. PUPULIN, Y. RÉMION. *Multiview acquisition systems*, in "3D Video: From Capture to Transmission", L. LUCAS, C. LOSCOS, Y. REMION (editors), Computer Engineering Series, Wiley-ISTE, December 2013, <http://hal.inria.fr/hal-00856832>
- [27] F. DEVERNAY, Y. PUPULIN, Y. RÉMION. *Systèmes d'acquisition multivues*, in "Vidéo 3D : Capture, traitement et diffusion", L. LUCAS, C. LOSCOS, Y. REMION (editors), Traité IC2, série Signal et Image, Hermes Lavoisier, September 2013, <http://hal.inria.fr/hal-00856827>

Research Reports

- [28] A. VAN DEN BERG. , *Analysis of Social Navigation for a Robot*, June 2013, <http://hal.inria.fr/hal-00839360>

Other Publications

- [29] I. GAFTON, A. SCHILTZ, L. LIAUZU, J. BRAIVE, M. PINO, G. LEGOUVERNEUR, V. DUPOURQUE, J. CAQUAS, M. CHETOUANI, C. SAPT, P. CATON, D. VAUFREYDAZ. , *Value analysis to outline the future of robotics in healthcare - PRAMAD project*, April 2013, Med-e-Tel: The International Ehealth, Telemedicine And Health Ict Forum For Education, Networking And Business, <http://hal.inria.fr/hal-00788643>
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