CONET Newsletter

INFSO-ICT-224053 www.cooperating-objects.eu **Issue nr.6, December 2009**

Contents

Editorial

Welcome to the sixth issue of the CONET newsletter. CONET is the EU FP7 network of excellence on Cooperating Objects, merging the fields of embedded systems for robotics and control, pervasive computing and wireless sensor networks. CONET focuses on establishing the field of Cooperating Objects within the research and industrial community, thus strengthening the position of Europe in the research landscape.

In this issue we have an article from ETH Zürich on real-time plant monitoring that should help people with a lack of green fingers maintaining their plants. This issues member profile has some information on the Delft University of Technology and the Embedded Software group that participates in CONET. Last but not least, there is an article from our associated member Pablo de Olavide University on active perception for cooperating objects.

If you are interested in obtaining up-to-date information about the CONET project please visit our website at: http://www.cooperating-objects.eu/

We hope you will enjoy this issue. ■

Koubachi – Real-time Plant Monitoring and Vitality Diagnosis

By Philipp Bolliger and Moritz Köhler, ETH Zürich

The Need for Plant Monitoring

Properly taking care of indoor plants can be a quite demanding and challenging task. The provision of ideal environmental conditions for plant growth requires a lot of attention and detailed domain knowledge regarding the correct amount of water, light, and fertilizer. We found that most people tend to simplify these problems by resorting to a daily routine – often resulting in plants being overwatered. Our own experience shows that it is particularly difficult to learn the plant's actual condition (i.e., if it has enough or maybe too much water, or if it needs more light) since the plant exposes its vitality status to the user only indirectly and with a considerable time-lag. Therefore, a common practice to determine the current soil humidity is to actually stick a finger into the soil, certainly not very accurate and not always a pleasant procedure.

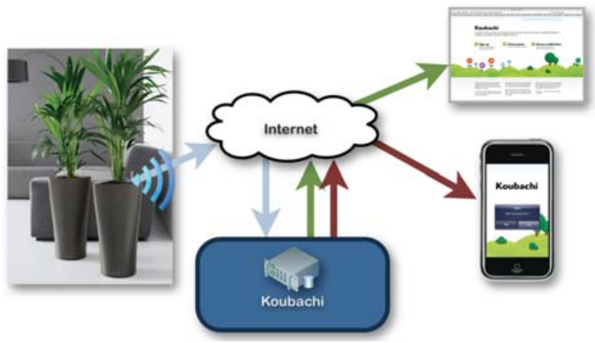

Figure 1: System Overview

However, the care itself is a very satisfying activity for most people as it gives the pleasurable feeling of accomplishment. Hence the idea emerged to augment indoor plants with new abilities to measure their vitality and to communicate their needs to humans.

We are pursuing this idea in the context of the ETH-spinoff company "Koubachi". The remainder of this article gives an overview of the plant monitoring system we are developing.

Plant Monitoring System

By remotely monitoring the environmental conditions at the plant's site, sending this data to a server and subsequently evaluating the plant's vitality, we can provide users with real-time care instructions and – in case of hazardous situations – alarms.

We developed a sensor that allows to measure the water-level in sub-irrigation planters. In addition, we measure the light intensity and air temperature as wells as humidity. The use of the latest WiFi technology allows us to build wireless yet battery-powered sensors.

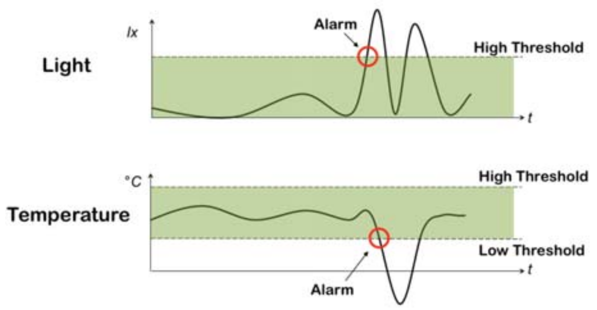

Figure 2: Threshold-based Alarms

To determine the vitality of a plant, we simply compare current sensor readings with a predefined threshold, as illustrated in Figure 2.

Moreover, the plant's status is only updated when a critical threshold of one or more sensor values has been exceeded for a specific amount of time. This prevents rapid changes of the visualization and should avoid alarming the human when a temporary suboptimal condition occurs, e.g., a temperature drop due to a sudden ventilation of the room. Of course, the parameters have to be set individually for each type of plant. Furthermore, since we record the data we may be able to indicate a critical situation before it occurs.

Data Presentation

In contrast to the Botanicalls[1] project, which has a similar focus but uses conventional telephone calls to report the plant's status, we aim to create a more affective interface. We chose this paradigm because of three main benefits: first, affective communication is universal for humans and is therefore not constrained by linguistic or cultural boundaries[3]. Second, we believe that emotional communication is a very effective means to trigger humans into doing something and third, by using emotions, one is able to build up a relationship with his or her communication partner[2].

Figure 3: Different Emoticons representing different states; way too hot, too hot and too much water

Hence, we decided to use the well-known "smiley" to visualize the plant's current vitality. Such smileys are often used to transport emotions in on-line communication and are therefore well-known amongst users. As they imitate a human face, recognition of the intended message is accomplished by interpreting the facial expression, which is intuitive and not hindered by cultural barriers.

We are using three states for the smiley: (1) A happy face, indicating that all parameters are within optimal values, (2) a neutral face, indicating that some parameters might pass tolerable values in the future, and (3) a sad face, indicating that one or more parameters of the plant show critical values. Furthermore, to advise the user of the concrete problem of the plant, we give additional visual clues. For example, if the plant was watered too strong, the smiley will be depicted in water, using a snorkel as depicted in Figure 3. The humorous illustration of the plant's state is intended as we believe it will help to create a relationship between the human and the plant.

To make plant care as convenient as possible, the user can not only get updates and alarms via email, SMS, or our website, but we're currently also implementing an iPhone application.

Contact

Further information can be found on the website www.koubachi.com. If you have any questions, ideas, or suggestions you can reach us by email at bolligph@ethz.ch, and mkoehler@ethz.ch.

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[1] Botanicalls: http://www.botanicalls.com/

[2] Picard, R.W.: Affective Computing. MIT Press (1997)

Member Profile: TU Delft

Delft University of Technology in the Netherlands is a modern university with a rich tradition. Although the University only received its current name in 1986, it has been providing technical education for 165 years. Its eight faculties and over 40 English-language Master programmes are at the forefront of technological development, contributing to scientific advancement in the interests of society. Ranked among the top universities of technology in Europe (#17, THES 2008) TU Delft's excellent research and education standards are backed by outstanding facilities, research institutes and research schools. TU Delft maintains close links with (inter)national industry, a strategic alliance contributing to the relevance of its academic programmes and career prospects for its graduates.

ⓘ **http://www.tudelft.nl/**

The Embedded Software (ES) group, which is part of the faculty of electrical engineering, mathematics and computer science, is led by prof. dr. Koen Langendoen (full time) and prof. dr. ir. Arjan van Gemund (part time). It is this group that actively participates in the CONET network of excellence. Although the ES group was only established recently (June 2008) and consists of just eight researchers and engineers, it has quite a track record in the area of Wireless Sensor Networks. In particular the group is known for being amongst the first brave research groups trying to put theory into practice by running a real deployment back then in 2005; the combination of home-brew node hardware, first generation software, and optimistic project management proved to be the right mix of ingredients for a valuable, even entertaining, learning experience documented in the famous "*Murphy loves potatoes*" paper. It inspired the group to develop new, more robust protocols that can handle real-world scenarios instead of the common traffic patterns exercised in simulations. The Crankshaft protocol – an energy-efficient MAC protocol for dense networks – is a fine example; typical simulation scenarios include only a few neighbouring nodes, say up to 20, while in practice almost all nodes on the potato field ended up being in the same radio cell as the agricultural researchers were interested in measuring the micro-climate with high spatial resolution. First generation MAC protocols like T-MAC were not designed to handle densities in the order of 100 nodes/cell leading to a total collapse wasting energy and providing low goodput rates due to contention and overhearing. Crankshaft therefore

carefully splits the available bandwidth amongst all nodes scheduling the sleep/wakeup intervals such that only small groups of (neighbouring) nodes become active at the same time.

The WSN community at large has realized that the number of skilled researchers needed to carry out a successful deployment is way too high, hampering the entrance of WSN technology into daily live. This has prompted many new directions of research and the Murphy's paper is often cited as a motivating example for research into proper development tools, high-level programming approaches, and robust/adaptive protocols that dynamically adjust to the (ever-changing) network conditions at the final deployment site. The Embedded Software group itself focuses its activities in this area on two projects.

Within the WISEBED project, an EU FP7 project involving 9 partners, the focus is on providing a multi-level infrastructure of interconnected testbeds of large-scale wireless sensor networks for research purposes, pursuing an interdisciplinary approach that integrates the aspects of hardware, software, algorithms, and data. To this end an extensive 100+ node testbed is currently being installed at TU Delft, which is planned to become operational in early 2010. In due time it will be made available to the academic research community as part of the WISEBED facilities.

ⓘ **http://www.wisebed.eu/**

Within the Darjeeling project, an open-source initiative by the ES group, the efforts concentrate on developing a convenient programming and development system for small embedded microcontrollers with limited resources. We have released a Virtual Machine that supports a large subset of the Java programming language providing object orientation, automatic memory management (garbage collection), and threading to application developers. The key to success is a combination of offline byte code analysis and transformation, and a well coded runtime environment that has a minimal memory footprint. In the near future we plan to work on over-the-air class loading to make the Darjeeling VM an attractive candidate for real-world deployments. Stay tuned!

ⓘ http://www.es.ewi.tudelft.nl/ ■

Active Perception for Cooperating Objects

By Pablo de Olavide University (UPO), CONET Associated Member

Introduction

Cooperating Objects (COs) involve different sensors and actuators that can communicate and cooperate for developing tasks. Among others, one very important task is information gathering. Other times, information gathering is essential to accomplish a given task.

The COs can cooperate in information gathering tasks by simply exchanging and fusing information (Merino et al, 2006), leading to a better understanding of the situation. However, they can go further as the COs can perform cooperative actions that improve their knowledge about the environment. This is what is called active perception.

The active perception problem can be defined as the procedure to determine the best actions that should be performed by the COs from the point of view of information gathering. In general, active perception can mean selecting sensory actions, for instance pointing a pan-and-tilt camera or activating a particular sensor of the network. If we consider mobile COs, active perception can mean influence a robot's path planning, e.g. given two routes to get to a desired location, take the more informative one (see Figure 1), etc.

Therefore, active perception involves decision making and control algorithms to determine which movements (and, in general, which actions) should be performed by the COs to obtain a better picture of the world.

Active perception is a relevant issue for COs as it allows:

- Optimizing the resources, for instance only activating those objects most informative.
- Coordinating the operation of COs in information gathering activities.
- Providing adaptation to the environment and the situation.
- Providing exploration rules for new environments.

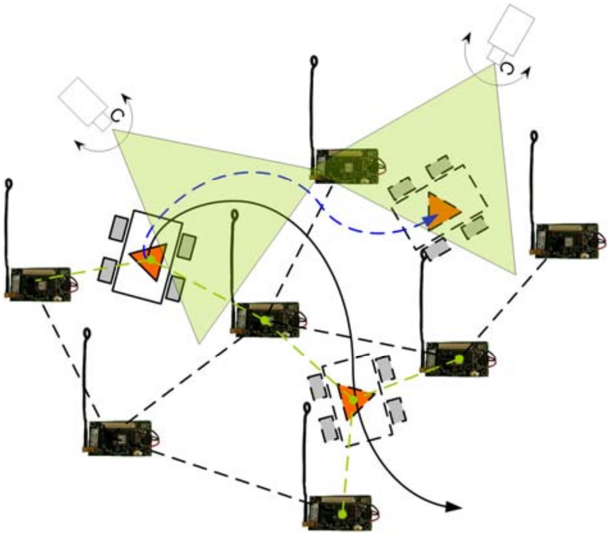

Figure 1 – Active Perception concept: a set of COs will take the more informative actions. For instance, if the estimation on the robot location depends on the cameras or sensor nodes (maybe because the robot does not have any location sensor), the robot may decide to take trajectories that are covered by many cameras (dashed) instead of other possibilities. At the same time, the most informative nodes would be activated.

Active perception requires to reason about uncertainties, which can arise from lack of observability, vagueness, sensor noise, etc. One important issue is to define measures of the amount of information available to the COs at a given instant. And, in order to determine the utility of a given action, it is required to define how to estimate the information gain that can be obtained when a particular action is carried out.

Information-theoretic active perception

There are many possibilities for representing and handling uncertainty, but one of the most important trends nowadays is to use probability theory for this purpose. In this case, the knowledge (also called degree of belief) is represented by probability distributions, and information-theoretic measures are employed for active perception, such as the entropy of a probability distribution, which gives an idea of how informative a particular distribution is.

Thus, a common technique for active perception is to compare the entropy of the current belief of the COs team with the expected entropy of future beliefs, provided that a certain action(s) is performed. If the entropy of a future belief is lower than the current one, the COs will have less uncertainty regarding the true state of the environment. This would mean that we have gained information.

Of course, this requires having the adequate (stochastic) models to predict future observations and the effect of actions on the environment. A policy that at the same time maximizes the expected information gain and minimizes action costs can be used for developing cooperative actions for perception purposes.

An example of this approach is given by Zhao et al. (2002). They present the application of tracking a moving target by means of a sensor network. The aim is not to use the whole network throughout all the time (due to energy optimization). The decision about the next node to activate is made locally by using information utility measurements.

Planning under uncertainties

The idea presented above has been used mostly for developing greedy control algorithms, in the sense that the objective is to decide which action is the next best action to be carried out, without taking into account long-term goals. Another option is to develop planning algorithms which at the same time take into account long-term goals, costs of actions and the information gain of these actions.

Planning under uncertainty is considered by POMDP (Partially Observable Markov Decision Process) techniques (Kaebling et al., 1998). POMDPs provide an elegant way to model the interaction of (uncertain) COs with an (uncertain) environment. Based on prior knowledge of the sensors' models and the environment dynamics, it can be used to compute policies that tell the COs how to act, based on the observations they receive. These control policies describe the behaviour of the CO along a wide variety of situations, considering long-term goals.

If the POMDP model is adjusted to allow for reward models that define rewards based on beliefs instead of states, it can be defined a reward model based on the belief entropy. A natural interpretation would be to give higher reward to low-entropy beliefs. This way the COs can be guided to choose actions that maximize their information, traded off by the cost of executing a set of actions (Spaan, 2008).

There are initial attempts to use POMDPs for active sensing. Guo (2003) presents a POMDP framework for active sensing, in which the actions are using a particular sensor (with an associated cost) or, when enough information has been gathered, outputting a particular classification label. Another example is (Chong et al., 2008), on approximations to use POMDPs in active sensing.

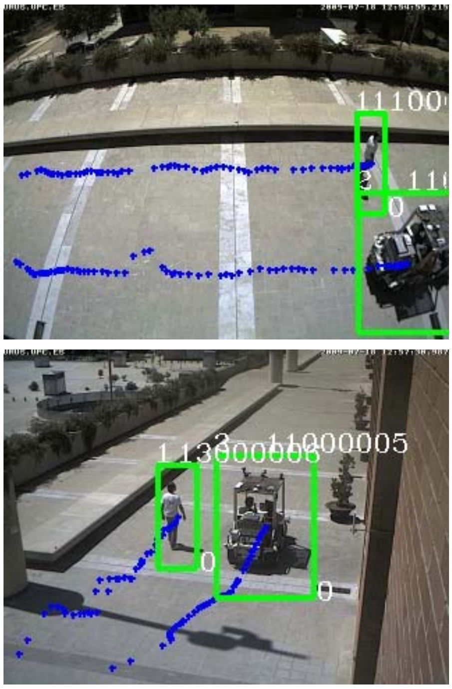

Figure 2 – Experiment in which a robotic car guides a person, with the help of a camera network. The cameras provide information on the person and robot position. The robot can decide to move through the (more informative) covered zones (from the URUS European Project http://urus.upc.es)

Conclusions

Considering information-related revenues when cooperative actions are performed allows to a set of COs to perform certain tasks more efficiently (see Fig. 2). Several approaches can be employed for this. Information theoretic measures used within POMDPs offers a principled framework for active perception in cooperating objects.

In the CONET cluster on "Mobility of Cooperating Objects", initial results on the use of POMDPs for controlling a network of COs in tracking applications (minimizing resources), and in the collaboration of mobile and static COs for localization have been obtained. The issues ahead are the scaling of these techniques to consider large numbers of COs, considering techniques like Decentralized POMDPs.

Contact

For more information:

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References

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Announcements

IEEE International Conference on Robotics and Automation, ICRA 2010

May 3-8, Anchorage, ALASKA

ⓘ **http://icra2010.grasp.upenn.edu/**

5th ACM/IEEE International Conference on Human-Robot Interaction, HRI 2010

March 2-5, Osaka, JAPAN

ⓘ **http://hri2010.org/**

CPSWEEK

April 12-16, 2010, Stockholm, SWEDEN,

ⓘ **http://www.cpsweek2010.se/**

The CPSWeek brings together four leading conferences – HSCC, IPSN, LCTES, and RTAS – as well as several workshops and tutorials on various aspects on the research and development of cyber-physical systems: Embedded Systems, Hybrid Systems, Real-Time and Sensor Networks.

16th IEEE Real-Time and Embedded Technology and Applications Symposium, RTAS 2010

April 12-15, 2010, Stockholm, SWEDEN,

ⓘ **http://www.rtas.org/**

7th European Conference on Wireless Sensor Networks, EWSN 2010

17-19 February, Coimbra, PORTUGAL

ⓘ **http://ewsn2010.uc.pt/**

First International Workshop on the Web of Things, WoT 2010
March 29, 2010, Mannheim, GERMANY

ⓘ **http://www.webofthings.com/wot/2010/WoT_2010_cfp.txt**

International Conference on Information Processing in Sensor Networks, IPSN 2010

April 12-16, 2010, Stockholm, SWEDEN,

ⓘ **http://ipsn.acm.org/2010/**

8th IEEE International Workshop On Factory Communication Systems, WFCS 2010

May 18-21, Nancy, FRANCE

ⓘ **http://wfcs2010.loria.fr/**

Work in progress Papers: 1 March, 2010
Notification: 6 April, 2010
Final Contributions (RP & WIP): 12 April, 2010

IEEE/ASME International Conference on Advanced Intelligent Mechatronic, AIM 2010

July 6-9, Montreal CANADA

ⓘ **https://engineering.purdue.edu/AIM2010/**

Papers: 1st February 2010
Notification: 7 April 2010
Final Contributions: 30 April 2010

19th European Conference on Artificial Intelligence, ECAI 2010

August 16-20, Lisbon, PORTUGAL

ⓘ **http://ecai2010.appia.pt/**

Abstract deadline: 15 February 2010
Papers: 22 February 2010
Notification: 30 April 2010
Camera-ready: 28 May 2010

IEEE/RSJ International Conference on Intelligent Robots and Systems, IROS 2010

October 18-22, Taipei, TAIWAN

ⓘ **http://www.iros.org/**

Papers: 28 February 2010
Notification: 15 June 2010
Camera-ready: 15 July 2010

Latest News

- The Chairs of the 7th European Conference on Wireless Sensor Networks (EWSN 2010) and the CONET Consortium are pleased to announce the **Master and PhD Thesis Award Competitions** in the area of Cooperating Objects. The prize is donated by CONET. Details in: http://www.cooperating-objects.eu/
- The **Cooperating Objects Roadmap** is now officially available for public download, see http://www.cooperating-objects.eu/roadmap/download/

Register @ http://www.cooperating-objects.eu/ to receive future issues of the CONET Newsletter