I/O Vivat

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Photo cover: 'No need for cords'

Bonsai in Japan

In February of next year 24 students and 5 professors will visit Japan to check out the latest developments in the field of smart surroundings. In Tokyo, Osaka and Kyoto a total of twenty universities and companies will be visited. These visits form the final part of an extensive research into the theme of the study tour, smart surroundings. This theme is best described as having computers help in our daily lives without us actually noticing them. To let others know about this fascinating topic, the magazine you are holding now is filled to the brim with articles concerning this theme.

First of all, one of our participants has written an article to clarify the meaning of the theme. There are also a number of articles written by the professors accompanying us for the tour, and their colleagues; these include topics such as ambient entertainment and sensor networks. Furthermore there is an article about privacy issues regarding smart homes and one about the challenges and potential of gesture interfaces.

Also, a symposium will be held at November 27th, which will include many interesting speakers, a lunch and informal drinks to end the day. This I/O Vivat is meant to give you an insight into what is happening at the University of Twente, while the symposium will include speakers from other universities and companies.

The symposium is called OrigAmi. It is originally a paper folding technique. Origami pieces are quite complex, yet consist of some very simple folds. Smart surroundings are also made out of objects a user can interact with in a very simple way. Combined they can cover a large and complex part of the user's life. The capital 'A' is there to emphasise the last three characters 'Ami' which is short for Ambient Intelligence.

To conclude this preface I wish you a lot of reading pleasure and I hope to welcome you to our symposium. ■

Isaac Pouw, Chairman Bonsai Study Tour

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News

A high-tech fashion style with smart fabrics

When searching the World Wide Web for some interesting news about smart surroundings, we stumbled upon the BBC News website. There was an item about a fashion show held at the SIGGRAPH exhibition. At the exhibition the newest technological innovations are shown and so were these clothes, that were made out of some interesting fabric. One such item was a bikini made out of solar cells to recharge your iPod or another mobile device that can receive power through a USB connector, although it's best you don't go swimming with it.

There was also clothing with some prints that can't be seen by the naked eye but when a digital camera is used, it reveals the entire beauty of the art. Another was a jacket with built-in LEDs. This jacket can display a personal message, but when you hold hands with your partner and he/she is also wearing the same kind of jacket, it detects the other one. A single message is then displayed over both jackets. You and your partner can show the world what you mean to each other.

Two pieces of clothing were standing out from the rest. The first is a dress, which has a number of motion-sensors built in. The costume is intended for performers, because the data can be used to create music or cue up video and audio, while you're dancing. With this dress you don't have to dance to rhythm of the music, but the rhythm adapts to your dancing. The second is a "collaborative videogame platform". It is a fancy name for underwear with 6 controller spots on it. The bra and the boxer become the gamepads to play custom made videogames. Let's hope that games like DOA or Tekken will never be ported to this platform, because these kind of games are famous for button-bashing.

Source: Mark Ward, BBC, http://news.bbc.co.uk/2/hi/technology/6934559.stm

Camera sums up your life for mall owners

NEC has developed a security camera that determines your age and gender. In the future it might even determine your social class. This camera, called FieldAnalyst, is not intended for tracking criminals or people who look like Osama Bin Laden. It is intended to help mall owners better understand their visitors. Already a few malls have installed the camera.

The guess of your age isn't very accurate yet, but it is very fast. It also guesses your age within ten years. NEC wants to narrow that range and even get to the point where it can determine your age within a year or two.

NEC points out that the FieldAnalyst does not store any data or record the images. Your privacy is not in any danger.

Source: news.com, 3 oktober 2007, Michael Kanellos, http://www.news.com/8301-10784_3-9790253-7.html

More Wii Motion-sensing fun

It has almost been a year since the Nintendo Wii became available on the Dutch market and most of the time it was sold out. The Wii featured a revolutionary controller that would get gamers active. Although the concept was sound in theory; in practice it was a different story. Most of the games only require small wrist movement and therefore can be played from the couch.

For those of you who have followed the latest E3 in July, you saw already that Nintendo renewed its offensive to get the gamers active again. Nintendo has announced three new custom controllers. The first two, the Wii Zapper and the Wii Wheel, aren't really shocking. These are just plastic moulds to put your Wiimote in. This has already been done by third party developers and probably wouldn't get you out of your lazy man's chair.

In contrast, the third addition is a welcome one: the Wii Balance Board is, unlike the Zapper and the Wheel, a true new piece of hardware needing the gamer to stand on the board. The board then registers the weight, centre of balance and where the feet or hands make contact on the board. This means that the gamer once more has to become active by using his entire body to play the games. For now Nintendo uses the Balance Board to reach non-gamers. The first game made for it is Wii-Fit.

By shifting your balance or stepping off and on the board, the player can do aerobics and fitness games in Wii-Fit. Next to Wii-Fit we can envision a number of concepts where the Balance Board will play a big role, like dance gamea or board-sports games. Nintendo has not yet announced when the Balance Board will be released, the maximum weight requirements or if it will come in different sizes.

Source: http://www.zdnet.nl/news.cfm?id=70409, http://www.gadgetzone.nl/nieuws.php?id=3876,
Source picture: http://www.engadget.com/2007/07/11/nintendo-wii-fit-gets-you-stepping/

Smart phones making us stupid says new study

In yet another piece of new research into the possible effects of the RF radiation emanating from mobile phones and its effects on human physiology, it is now being alleged that the frequent use of mobile handsets can slow human brain function.

The study says there is evidence to suggest that alpha and theta brain wave activity and "Alpha Peak Frequency" are influenced by the heavy use of mobiles.

According to a joint statement from the Brainclinics Diagnostics, Radboud University in the Netherlands, the Institute of Psychiatry in London and the Brain Resource Company Ltd in Sydney, the research considered the long-term effects of mobile phone use on the brains of 300 people. The study group was divided into 100 frequent mobile phone users, 100 non-mobile phone users and 100 intermediate users.

Martin Arns, the lead investigator in the study cautions that "the slowing found in this study, with mobile phone users, can still be considered within 'normal' limits" but considering "the time of data collection - only 2.4 years on average which can currently be considered as a short time therefore, it is to be expected that the observed effects in this study can be more severe with prolonged mobile phone use."

On the other hand, the researchers point out that no "firm conclusions" can be drawn as to whether "this slowed brain activity is to be considered as an adverse health effect or not," until much larger groups of subjects are studies for a longer period.

Source: http://web20.telecomtv.com/pages/?newsid=41897&id=e9381817-0593-417a-8639-c4c53e2a2a10&view=news

RFID still quite unknown

A recent survey about RFID had some interesting results. Two thousand Dutch people were questioned and almost two thirds of them don't know what RFID is, even though most of them are already carrying a RFID chip.

Most people don't know that the new Dutch passport, the OV-card (public transportation) or employee cards contain these kinds of chips. Almost halve of the correspondents think that employers will use the chips to monitor them. When asked if they would use the chip if it keeps track of their working hours for them; 30% would do so, while 38% is neutral to this idea.

RFID in the supermarket is less accepted. 87 percent wants the chip readers to be clearly visible. 68 wants to know if a product contains a chip and 53 percent wants the chip to be deactivated after purchase of the product.

Source: "Chip in bedrijfspas mag, op een panty liever niet; Accent Identificatiechips", de Volkskrant, section Economie; page 7, 28 september 2007

Korean law for ubiquitous city

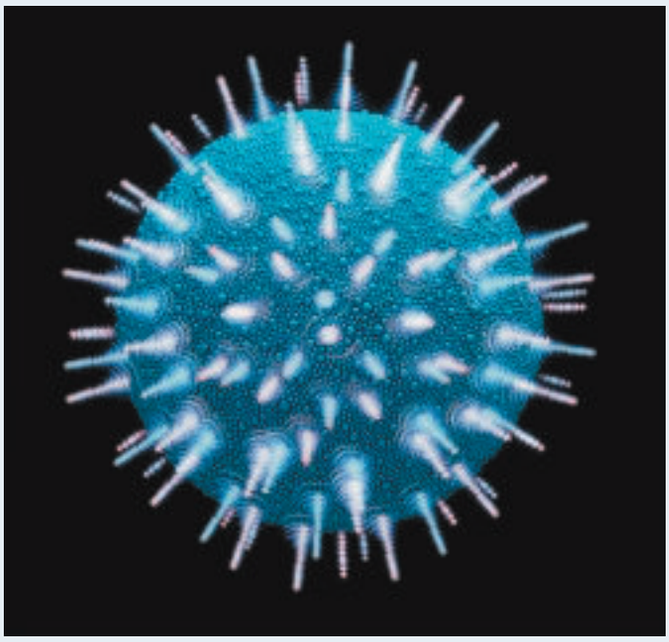
The government of Korea is planning on making a legislation that makes it mandatory to create a ubiquitos city. The law will be effective starting next year, it states that every newly created city bigger than 3.3 million square meters must be turned into a ubiquitos city. This is defined as a city where citizens can go online everywhere they want and it must supply accurate information about for example transportation that is gathered by intelligent sensors. The law will be submited in November.

Source: http://www.korea.net/news/news/newsView.asp?serial_no=20070916009

Spam blockers target HIV

As everyone knows, "viagra" is a word notoriously known for the amount of spam about it. The spam blockers cannot simply block "viagra" as the spammers invent small variations of the word that get past the spam blockers. This has some key features viri have too; they continiously mutate to evade the defense system of other living things.

This lead David Heckerman, a physician and software engineer, to use the techniques used for spam detection for detecting HIV. HIV does, like any other virus, infect cells by injecting a copy of its genetic material changing the cell. This copying is done in a very sloppy manner, which basically means that each cell is infected with different genetic material. The infected cell starts hatching the offspring of the infecting virus, but due to the mutated genetic material a lot of cells will not produce a viable virus, but a few will produce an even better version of the virus which the medication does not recognize.



Currently Heckerman and his team are analysing thousands and thousands of (infected) cells to determine the minute difference between infected and uninfected. This should then help the development of effective vaccines.

From: "Using Spam Blockers To Target HIV, Too", BusinessWeek, 1 October 2007.

Gesture Recognition

At the Createc trade show last month, Japanese companies introduced their latest products to the public. The most-used new technology in consumer electronics products is gesture recognition.

Toshiba for example presented a PC that is operated by hand gestures. Hitachi introduced a product called "Magic Waters". It works by pointing the wand at the fountain, which causes the water to jump. Sharp presented an 'iPhone-like' interface for mobile phones. Pioneer has a car navigation interface that uses finger gestures.

Unfortunately, it will probably take a few years before we will see these products enter the European market.

Source: http://www.news.com/8301-10784_3-9790323-7.html

Human-robot Relations

Roombas, little vacuumcleaners that operate on their own, are so cute looking that people actually get attached to them. A recent research at the Georgia Tech's College of Computing showed that owners don't mind if their robots aren't perfect, simply because they treat them as a pet.

Some owners even dress up their Roombas. Others 'roomba-izen' their room: they change it so that the robot can vacuum the floor more easily. This can be done by buying a fridge that has a high enough clearance for the robot to pass through, buy a new rug or even preclean the room.

"I was blown away," tells Ph.D student Ja Young Sung, who studies Emotional Design. "Some Roombas break a lot, they still have functional problems. But people are willing to make that effort because they love their robot enough."

Source: *Study Finds Human-Robot Attachment*, http://ap.google.com/article/ALeqM5g3XmOrAtTPQf3PUT2Nugj-rYes5wD8S0S6O00

Roomba normal

Roomba pimped (with additional cat)

I.C.T.S.V. Inter-*Actief*

Hammertime!

"Partir, c'est mourir un peu", as the French say. Leaving means dying a little. How better to experience this than to suddenly stop doing what has been present in every aspect of your life. Of course, I'm talking about the recent coup d'état in Inter-*Actief*. Five people who had been working practically fulltime to get where Inter-*Actief* is now, made place for five fresh board members. Whether Inter-*Actief* is in better shape at the end of a year of Johan, Tom, Bert, Erwin and myself, was the main question on Monday, October 2nd. One last time, we looked back at the policy we exerted, and the course we had laid out and the course we had actually covered.

The general assembly quickly came to conclude that Inter-*Actief* had managed to avert the cliffs in 2006-2007. This conclusion would lead tot the penultimate event of me chairing Inter-*Actief* for twelve months: hitting a little board on a table with a hammer, discharging the 28th board for what happened to I-*A* in fifty-two weeks of 2006 and 2007. As I swung the hammer towards the little board, all 365 days in which me and my four colleagues wielded the scepter flashed before my eyes. Every board meeting, every time we worked late and ordered out, every quarrel, everyone who came to ask if the coffee was still fresh, every 'borrel', especially all the free beer. After suddenly realizing that I was still supposed to actually hit the little board on the table (and that I would have all the time of the world to try and calculate exactly how much free beer I had consumed later), one very special year for me and my colleagues as Inter-*Actief*'s board, ended.

Of course being a board member was great fun, but it can be as much fun to act like a moody former board member. However, to get back tot the French cliché that started this sentimental outburst, the people of the country of "du vin, du pain, du Paturain" do have a point. Everyone of us, the 28th board of I-*A*, invested a lot of ourselves in our great study association. That investment is what we left behind as we passed on the responsibility of trying to keep Inter-*Actief* on track. But to call that dying a little, is a bit to negative for my taste. On the contrary, I hope that what me and my colleagues have put into I-*A* last year, and what Rick, Mattijs, Pim, Joep and Elger will invest this year, will keep Inter-*Actief* alive and kicking for many more years!

As this is the last time I get to write a foreword as (former) chairman of Inter-*Actief*, I would hereby like to thank everyone who put their faith in us to lead Inter-*Actief*, everyone who supported us as an active member of the study association, everyone who attended any one of the activities of 2006-2007, and especially my colleagues Johan, Bert, Tom and Erwin, for a great year! ■

Sjoerd van der Spoel

voorzitter 2006-2007

I.C.T.S.V. Inter-*Actief*

My daily life and smart surroundings

While thinking about what to write I started my laptop. Because I still didn't have much inspiration I also wanted to see my agenda for tomorrow and noticed that my new smartphone and the agenda on my laptop didn't match. To synchronize these two agendas I only have to turn on my Bluetooth. Even though this event costs as much time as writing this paragraph, it still consumes time.

This is where smart surroundings comes into play. Instead of starting my laptop, the "surrounding" detects my presence and starts my laptop and by using eye scan I can log in. Checking whether my agenda's match isn't necessary anymore, my laptop or smarthphone detects another device with an agenda and connects automatically. Synchronizing happens without any user interaction. Because I want to know the appointments I have, all the appointments I have today are displayed on my mirror or television depending on the room I'm in. When I leave the environment my laptop starts to hibernate and the appointments disappear from the television.

The scenario which I describe covers the main aspects of smart surroundings. The devices, my laptop and Smartphone, are embedded into the environment and recognize me and other devices. They recognize me, by using the eye scan I can login, and the devices adapt to my needs by listing my appointments. When I enter another room the environment adapts, the mirror in the bathroom shows my appointments. The environment also detects when I want to leave and anticipates to this action.

This is only one example of smart surrounding and how it can help me in my daily activities. Again while writing this article, I'm thinking about a lot of ways how Smart Surrounding will influence my life. I only think about a few aspects of Smart Surroundings, however Smart Surrounding can be used everywhere.

That is why I'm looking forward to the OrigAmi symposium on the 27th of November. The symposium will not only address the living & care aspects but will also address Education & Entertainment and Work & Travel. Hopefully I'll learn more about the use of smart surrounding in my daily life.

I hope to see you all on Tuesday the 27th of November. ■

Rick Leunissen

voorzitter 2007-2008

Symposium and Tour

the different sides of Bonsai

Symposium "OrigAmi"

Ever since our committee started we said that we would not only organise a study tour: we set ourselves the goal to organise a symposium as well. This goal has been realised in our symposium called *OrigAmi*. By now you might wonder what our symposium is about. Well, it is about smart surroundings.

What is smart surroundings?

According to Google, 'Smart Surroundings' is an interior decorator company (http://www.smartsurroundings.com). This, of course, is not what our symposium is about. Our symposium is about smart surroundings which is also known as Ambient Intelligence. It means that our surroundings become context aware. By adding small computers and sensors in everyday objects our environment becomes aware of events happening to itself or in its vicinity. Through some simple computer programme or a sophisticated Artificial Intelligence the object is capable of reacting to these events. One might consider a house that will call the emergency number in emergencies as an example of smart surroundings, but even a simple environment like a train that would give you the opportunity to continue your work during the journey as if you were at your office. Another nice example is a mobile device that will offer you a story or relevant information about the place you are at that moment.

What can I see at the symposium?

Our programme begins with a keynote lecture and ends with an endnote lecture and a discussion. The rest of the day is divided in three tracks *Education & Entertainment*, *Living & Care* and *Work & Travel*. In these tracks a number of examples are given of how smart surroundings already influences or in the future will influence our daily lives. The symposium will give a glimpse of what the future holds in store.

What else is there that day?

Of course we will provide a nice lunch for those who have registered themselves for the symposium and during breaks coffee, tea and other refreshments will be served. There will be some promotional stands from our partners at the symposium and some of them might bring some nice surprises. After the symposium we invite everyone for some fresh and relaxing drinks at the Inter-*Actief* bar in the basement.

The committee. From left to right: Rick Leunissen, Ivo van Hurne, Ronald Volgers, Niek Hoeijmakers, Isaac Pouw; not on photo: Remko Bijker

The 27th of November is the day for you to relax from your studies and enjoy a nice day of getting well informed about smart surroundings. The Waaier Building will be the place to be and we hope that we will see you all at OrigAmi. ■

Niek Hoeijmakers
External Relations and Symposium Coordinator

Study Tour Bonsai

Besides organising the OrigAmi symposium, the same committee has an even bigger task: organising a study tour around the topic of smart surroundings. This magazine should already give the reader plenty of information about what smart surroundings is, but in the context of a study tour the question becomes: where can we find it?

The answer is, of course, Japan! Besides always being at the forefront of technological developments, a remote country such as Japan offers the interesting cultural context that makes a study tour such a unique research opportunity.

"Where can we find it?"

A study tour considers not just the technical side of things which one could possibly study just as well from the Netherlands, but also the many different factors that might influence the development and deployment of these technologies in Japan. By comparing these factors with what we have found in The Netherlands we are then able to provide a unique perspective on our chosen field, smart surroundings.

To gain this perspective, it is not enough just to go to Japan and write down what we find. Without preparation we would not be able to ask the right questions, nor understand the significance of the answers we find. For this reason, each of our participants will have already completed 300 hours of research before we land in Japan. This research is bundled in our Preliminary Report, which is shipped to every company we cooperate with on this study tour before the trip begins in February 2008.

Of course, things will not slow down once we arrive in Japan. In three short weeks we will visit 20 companies, universities and research institutes that have to do with smart surroundings. We will visit the cities Tokyo, Kyoto and Osaka, making short trips to nearby places when needed. We will sleep in a variety of hotels, from urban to traditional, and eat dinner in tens of different places. There will of course also be some free time to see the sights of Japan and get a taste of the local culture.

Afterward, the things we have seen and learned in Japan will be brought home and collected and published in the Final Report, which marks the formal end of the study tour.

Because Japan is such a huge, diverse (and just plain fascinating!) country, we expect many of our participants will choose to stay in Japan for a short while after the program of the study tour itself is over. Although we do not expect them to record their experiences during this time, we expect they will return with many interesting stories to tell.

I hope all of our participants will find the experience rewarding, and as a member of the organising committee I would like to sincerely thank them for all their hard work so far. ■

Ronald Volgers
Secretary and Research Coordinator

This year Inter-*Actief* organises a study tour to Japan. In February 2008 the five headed organising committee will be accompanied by nineteen students and five teachers to visit the Japanese cities of Osaka, Kyoto and Tokyo. The theme of this study tour (and of this magazine) will be "smart surroundings". To study the current state of this theme in Japan the travelling party will spend three weeks in Japan, visiting twenty different companies, institutes and universities. Japan is of course a front runner when it comes to technological developments. Looking at the technology sector it becomes clear that Japan has a dominant position in the world. Big companies like Sony, Sharp, NEC, Canon, Panasonic and Pioneer are just a couple of examples that make Japan the technological giant it is. But what exactly is this theme mentioned above? What does "smart surroundings" actually mean? That is the question I will try to answer.

Smart Surroundings

what it is and isn't

Smart surroundings is a new paradigm that predicts a future in which people are surrounded by flexible, integrated information systems that are interconnected by (wireless) networks. These information systems provide support for a very diverse range of activities, but do so in an invisible and unobtrusive way. They are woven into the fabric of everyday life so to say.

To clarify what I mean by systems that support our activities in an invisible and unobtrusive way it is relevant to look at what is probably the first information technology ever invented: writing. Writing gave us the ability to capture a symbolic representation of spoken language for long term storage. It freed information from the limitations of human memory. Today this technology is ubiquitous in the industrialised world. Everywhere you look you find written language. From books, magazines and newspapers to street signs, commercial billboards and candy wrappers. The products of this "literacy technology" are everywhere and constantly present, but do not require active attention. The information that is stored is ready for use at a glance. The impact this technology has had on the world is tremendous. It is very hard or maybe even impossible to think of the modern society without written language.

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it. This is because of human psychology rather than the technology. When people learn something well enough, they cease to be aware of it. According to several prominent philosophers and psychologists it is only when we are able to use these new technologies without conscious effort we can focus on new goals beyond the old ones.

Smart surroundings is all about silicon based information technologies that, as with the above described writing analogy, are supposed to integrate into our everyday life. But the current situation is quite different. Although there are probably already more personal computers in the Netherlands than there are inhabitants, the computer still stands in a domain of itself. The personal computer is only approachable through complex jargon and difficult programming languages that have little or nothing to do with the task for which people actually use computers. This could be compared to the period of time when scribes had to know as much about making ink or baking clay as they did about writing.

Something that is the direct opposite of the smart surroundings paradigm is having a powerful laptop with access to a worldwide information network from all around the world. Such a laptop still focuses all attention on a small box. By analogy to writing, carrying a super laptop is like owning just one very important book. Customising this book or writing thousands or even millions of other books, does not begin to capture the real power of literacy. Additionally, because present day computers focus so much attention on themselves, it is not possible for them to fade into the background.

Perhaps most diametrically opposing the vision of smart surroundings is "virtual reality". It tries to create or simulate a world inside a computer and make it accessible to humans, who are equipped with special goggles and suits that sense their motions and gestures. It certainly does not try to enhance the existing world in an invisible manner. The opposition between virtual reality and ubiquitous computing is so strong that some people use the term "embedded virtuality" to refer to the process of drawing computers out of their electronic shell. The "virtual" is launched into the physical world.

But how would computers fade into the background? Actually, some ex-

amples already exist. Consider thermostats, stereos, and ovens. How often are you aware of your thermostat regulating room temperature in your house or apartment? For computers to weave into the fabric of everyday life computers need to be aware of their surroundings. Only then can they be smart. A thermostat that is unaware of the temperature in its vicinity would probably do a lousy job. But this also goes for your PC or laptop. If a PC merely knows in which room of the house it is located, it can adapt its behaviour in ways that does not require the slightest hint of artificial intelligence.

"By analogy to writing, carrying a super laptop is like owning just one very important book"

To see what smart surroundings will do for us in the not-too-distant future, we have to look at some of the implications of this paradigm. What if tiny, wirelessly interconnected computers were integrated into all everyday objects? Using small sensors, such embedded processors could detect their surroundings and equip "their" object with both information processing and communications capability. This would add a completely new dimension to such objects. They could find out where they are located, what other objects are in their vicinity, and what has happened to them in the past. They could also communicate and cooperate with other "smart" objects and perhaps access all sorts of relevant information on the internet. Objects and appliances could thus react and operate in a context-sensitive manner and appear to be "smart", without actually being intelligent.

The constant advances in the fields of computer science, micro electrics, communication technology and material science make smart surroundings very much a possibility. Ubiquitous computing could trigger a completely new set of applications, where cooperating objects create new emergent functionalities. The comprehensive computerization and interconnection of everyday objects would also be successful from a business point of view. This would doubtless have enormous economic and social implications. It would also raise issues relating to technology acceptance, privacy concerns and the creation of a world in which reality, to some degree, merges with our information-based cyberspace. The economically viability and the issues described above will decide whether we see these innovations tomorrow, in ten years or maybe never.

A practical example might be useful. In a research paper written by Maria Lijding and others I found a nice example of smart surroundings. Consider the workshop of a big research project or a commercial seminar. After the last morning session, the participants head to the restaurant for lunch, which will be served in another building. When the participants leave the meeting rooms they consult the Smart Signs attached next to the doors and in corridors. As a participant approaches a Smart Sign, it displays a group-message (Follow the arrows to the restaurant) and an arrow pointing in the right direction. Some participants like Peter, who is currently on crutches, and Maya, who uses a wheelchair, receive a personal message and guiding arrow, which routes them via paths without stairs. Halfway to the restaurant, a sudden fierce rain shower triggers the Smart Signs system to re-route the participants through a longer route to protect them from getting wet. One of the participants, Toni, suffers from epilepsy. He is wearing a context-aware monitoring device that connects him to a health-care centre that warns him of an imminent attack and sends help when necessary. During an evening session, Toni faints and his monitoring device contacts the health-care centre and announces the emergency locally. This 112-like call for help can be picked up by devices of doctors and paramedics in the vicinity—similar to someone shouting "Is there a doctor in the room?". The Smart Signs system reacts to this emergency by flashing a call for help and show guidance to get to Toni. Another emergency procedure of the Smart Signs system is to guide everybody to the nearest fire exit and mustering station in situations when the building must be evacuated.

Taken to its ultimate conclusion, a world made up communicating smart devices will most certainly lead to a significant change of the perception of our surroundings. It will trigger substantial social and economic changes that will ultimately be of political relevance as well. The social and cultural consequences of such developments are still very unclear. Though one thing is very clear; our personal privacy will certainly be affected, since cheaper, smaller, and more effective sensors and processors will allow for a much more comprehensive, automated surveillance of the environment, including where we go, what we do and what we say.

For the student participating in the study tour, this visit to Japan offers a very unique experience, maybe even an once-in-a-lifetime opportunity. The "smart surroundings" theme will offer an intriguing view into the Japanese society. When we return, hopefully we will have acquired a base of knowledge about the theme, some familiarity with the Japanese business culture and a cultural experience that we will not quickly forget. It will be a great adventure! ■

S.X. Koperberg
Bonsai participant

Dept. of Computer Science

What is Van der Hoeven searching for?

Counselling?

An interesting characteristic of human evolution is the development of our capability to improve the conditions of our miserable existence and to enhance our limited innate capabilities by the construction of "tools". We can move on our legs, but we can move easier and faster in a car. We can swim, but a ship carries us further, faster and easier. We have a voice, we can speak to a person nearby, but by telephone we can communicate over any distance. We have eyes, we can look at our nearby surroundings, but on television we can see the world. We are no birds; we have nothing to fly with. But by plane we can.

Interestingly each of these "tools" has its own evolution. Sometimes we even see a true battle of species among them, and a survival of the fittest. What happened to the zeppelin, and to the tape recorder?

With the image of the evolutionary development of a toolset to help us through life in mind, what is "smart surroundings"? The phrase sounds like it is the next step in the evolution of dead things. We want them to have a capability which resembles intelligence. And we will equip some of them at the same time with a basic understanding of the workings of the human mind. That feels like a ridiculously ambitious undertaking. And at the same time it seems a matter of course. Smart surroundings is the logical next step in our world picture.

The next step in the evolution of dead things. It was how I understood the conceptual essence of smart surroundings or ambient intelligence, listening to enthusiastic advocates of the research efforts in this direction. And then, by accident, I looked at the text of another presentation on the subject.

It spoke of "human integration", and "considering the user as an integral part of the system". I am stupid, I have been looking at the world from the wrong end. The dominant players are the tools, not us, the humans. The essence of smart surroundings is, that the tools now think they should look at us as an integral part of the system.

My opening paragraph needs correction. Humans and tools follow their own paths. The question what the conceptual essence of "smart surroundings" is, is not so relevant. The real challenge is another one, and it is huge. Somewhere along the line, thinking about humans and society, and thinking about technique, have grown apart. They need counselling to restore their relationship. I hope that each participant in the Bonsai tour will become a counsellor, who can help two ways of thinking to reconcile. ■

Gerrit van der Hoeven

Director of education

The Great Barrier Reef (GBR), located along the north-east coast of Australia is made up of over 3,200 reefs and extends over an area of 280,000 km^2. The scale of the fluctuation of environmental parameters in the GBR, ranges from kilometre-wide oceanic mixing to millimetre-scale inter-skeletal currents. Being able to monitor such parameters (e.g. temperature, light, etc.) at real-time and at a high spatial and temporal resolution would enable scientists to better understand the underlying complex environmental processes that help shape the behaviours of the biological and physical characteristics of the GBR.

Bringing the Great Barrier Reef Online

using Wireless Sensor Networks

The Australian Institute of Marine Science (AIMS), which is one of the world's leading research centres focusing on marine environments is at the forefront of carrying out research on various aspects of the GBR. Currently AIMS has a test site at Davies Reef which is located around 80km from the shore of the main AIMS research facility at Cape Ferguson. In the present set-up at Davies Reef, temperature data is logged using one data logger that has two sensors attached to it at two different depths. Samples are taken once every 30 minutes and stored within the data-logger. This data is subsequently transmitted to AIMS via a 3.3MHz HF radio.

The main drawback of the current setup is that it only allows single point measurements. This makes it impossible to get a true representation of the temperature gradients spanning the entire reef which is approximately 7 by 3 kilometres. The bandwidth limitation of the HF radio also makes it impossible to study the fluctuations of various environmental parameters in real-time. Having high-resolution data streaming in from the reef would not only improve understanding of various environmental processes (e.g. coral bleaching) but would also have immediate benefits to society at large. For example, as the data will be made available to the public, the tourism industry will be able to tap into the information to better understand diving conditions. The fishing industry will also benefit from knowing how temperature changes and gradients affect fish behaviour. Data collected by the sensors could also be used to study the effects of excess fertiliser washed off from the agricultural lands on the coast of Queensland.

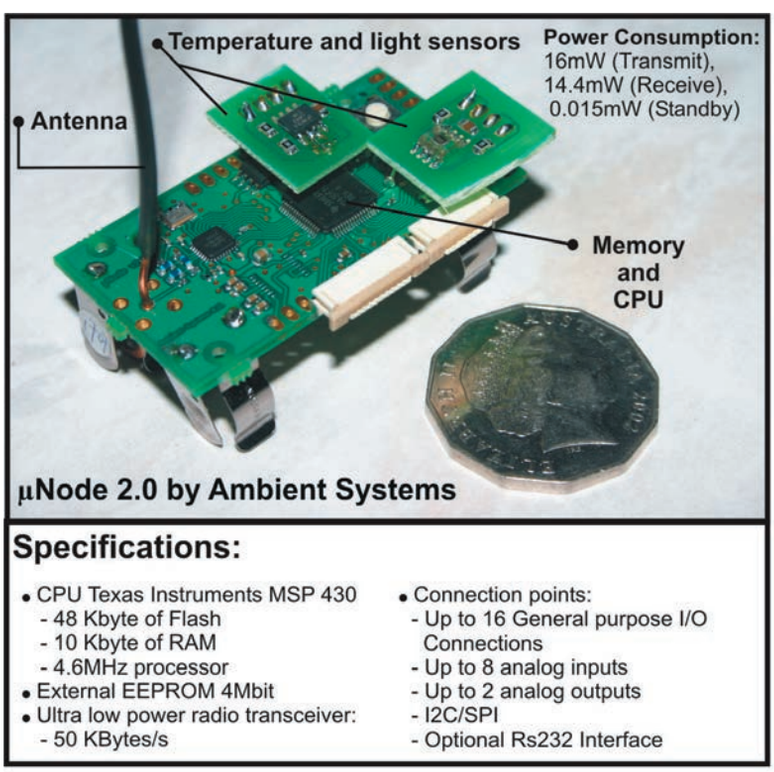


Figure 1: A typical example of a wireless sensor node

Researchers at the University of Twente and Ambient Systems in the Netherlands have been working closely with scientists at the Australian Institute of Marine Science (AIMS) to develop a large-scale wireless sensor network (WSN) that will enable the GBR to be monitored at extremely high spatial and temporal resolutions. Monitoring the physical parameters of an environment at such high resolutions is something that is currently not possible using existing data logging hardware.

What are Wireless Sensor Networks?

WSNs are typically made up of hundreds or even thousands of tiny energy-efficient, battery operated sensor nodes with built-in wireless transceivers (Figure 1). Every sensor node also has a CPU, a small amount of RAM and a number of general purpose I/O connections to connect various types of sensors. It is important to realise that sensors nodes are different from sensors which simply have radio transmitters attached to them. Unlike sensors with wireless transmitters, wireless sensor nodes are able to process the data within them before transmitting the sampled data due to their built-in computational capabilities. So for example, if a sensor node acquires a reading that is faulty, it could decide to drop the message instead of wasting energy transmitting it. Similarly, a sensor node may even drop duplicate messages.

As individual sensor nodes may have limited communication range (e.g. around 50-100 metres) communication in a WSN is typically done through a multi-hop network. So instead of transmitting data directly from a sensor node to the base station, data from a sensor node can be relayed through a number of intermediate sensor nodes, before it finally reaches its destination. This enables the network to cover a much larger geographical area. Figure 2 illustrates how the sensor node (from Ambient Systems) will be placed in a weather

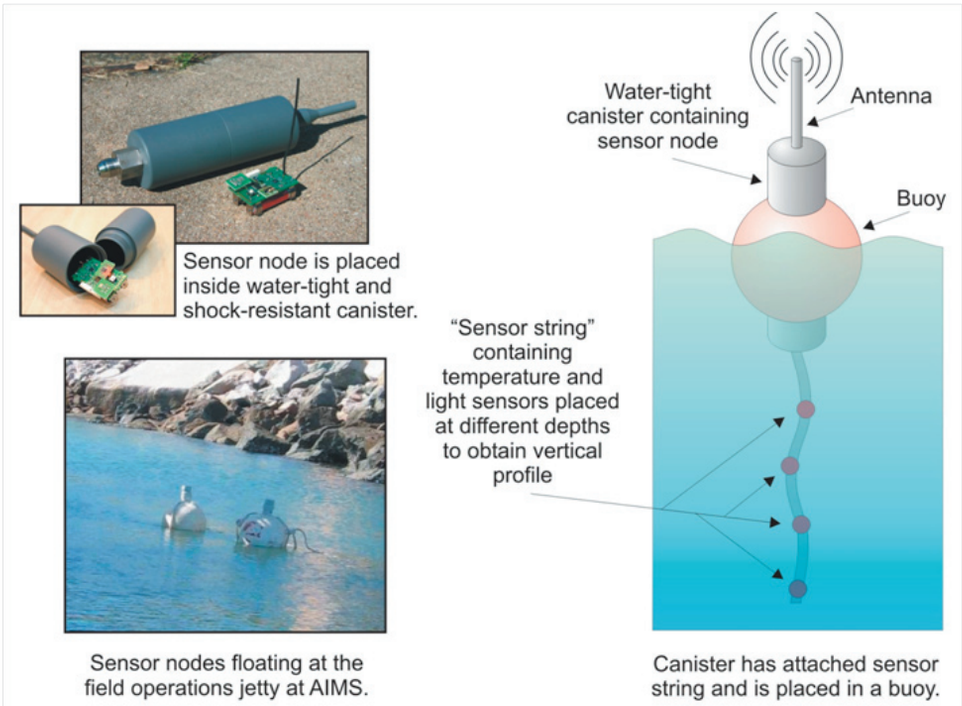


Figure 2: Buoys fitted with "sensor strings"

proof canister and then into a buoy. Every canister will have a sensor string attached to the bottom which will allow a vertical temperature profile to be created. These buoys, which will then be spread around the entire area of Davies Reef, will transmit the data over to base station located at a tower that has been erected on the sea floor. The microwave communication system on the tower subsequently transmits the collected data to the AIMS research facility 80 km away as shown in Figure 3.

The fact that sensor nodes are usually battery powered means that the amount of power available for a node to operate properly is highly limited. Such tight energy usage restrictions mean that energy efficiency has to be of paramount importance when designing any protocols for WSNs. There are generally two significant sources of energy consumption in sensor nodes: the operation of the wireless transceiver and the operation of the sensors attached to the sensor nodes. The sensor network platform we are deploying on the GBR takes both of these sources into consideration to ensure that the lifetime of the network can be maximised to run for a few years without battery replacement.

"Data collected by sensor nodes is usually transmitted to the base station through intermediate sensor nodes"

As mentioned earlier, data collected by sensor nodes is usually transmitted to the base station through intermediate sensor nodes. This results in a parent-child relationship such that communication is performed through a tree structure as shown in Figure 4. The problem with such a structure is

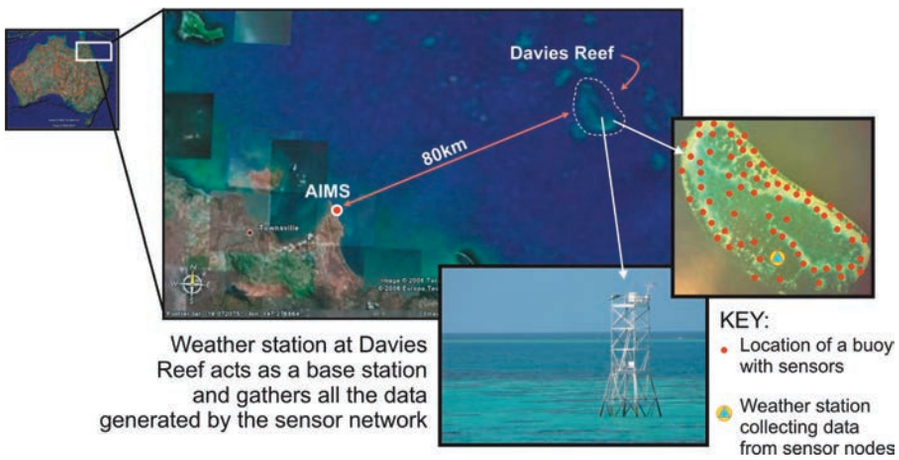


Figure 3: Data collected by the sensor netword is transmitted to AIMS via a microwave link

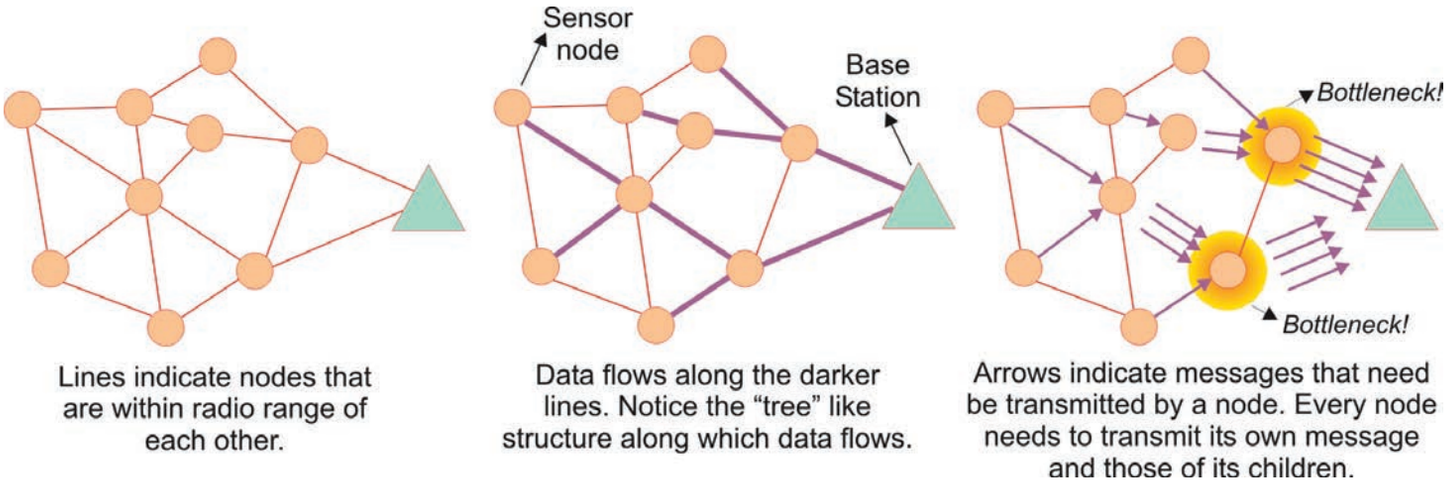


Figure 4: The disadvantage of collecting raw data

that as the collected data propagates towards the base station, the intermediate nodes that are closer to the base station are required to transmit far greater amounts of data than their counterparts who are further away. This results in two problems. Firstly, due to the larger amount of data that needs to be transmitted, nodes closer to the base station tend to exhaust their energy reserves earlier. This causes the nodes lower down in the tree to be "cut off" thus resulting in a disconnected or partitioned network. Secondly, as the sensor nodes typically have a low bandwidth, nodes closer to the base station are unable to relay all the received data to their parent nodes. This results in a substantial amount of lost messages which in turn has an adverse effect on the quality of data collected.

"Certain nodes in the network could always fail"

Processing data within a Wireless Sensor Network

In order to alleviate the problems mentioned above, we use a distributed data aggregation algorithm that reduces the amount of data that needs to be transmitted by taking advantage of spatial and temporal correlations that exist in sensor readings between neighbouring sensor nodes. As illustrated in Figure 5, instead of having every node transmit its sensor reading, we assign specific roles to the various sensor nodes – a node can either be an *aggregating node* or a *non-aggregating node*. Aggregating nodes are put in charge of figuring out whether a correlation exists between itself and its neighbours which are one hop away. For example, the neighbouring node N2 might always be 1.7°C above the aggregating node N1 while N4 might always be 0.2°C below node N1. In such a scenario, the aggregating node N1 would first send the correlation information describing how its readings are related to its correlated neighbours to the base station and subsequently, this would be followed by its own readings. Thus if for instance the temperature reading of N1 increases, the base station would be able to compute the readings of all the other neighbours of N1 that have correlated readings. Nodes that do not have correlated readings, continue to transmit raw sensor readings. As correlations may not be constant through out the day, our algorithms are able to adapt to varying correlations.

Since the network will be deployed in a harsh environment, certain nodes in the network could always fail. However, our aggregation algorithm is designed to work seamlessly even when certain nodes fail or if new nodes are added to the network. This also ensures that the network is easily scalable. Thus our sensor nodes are capable of making completely autonomous decisions

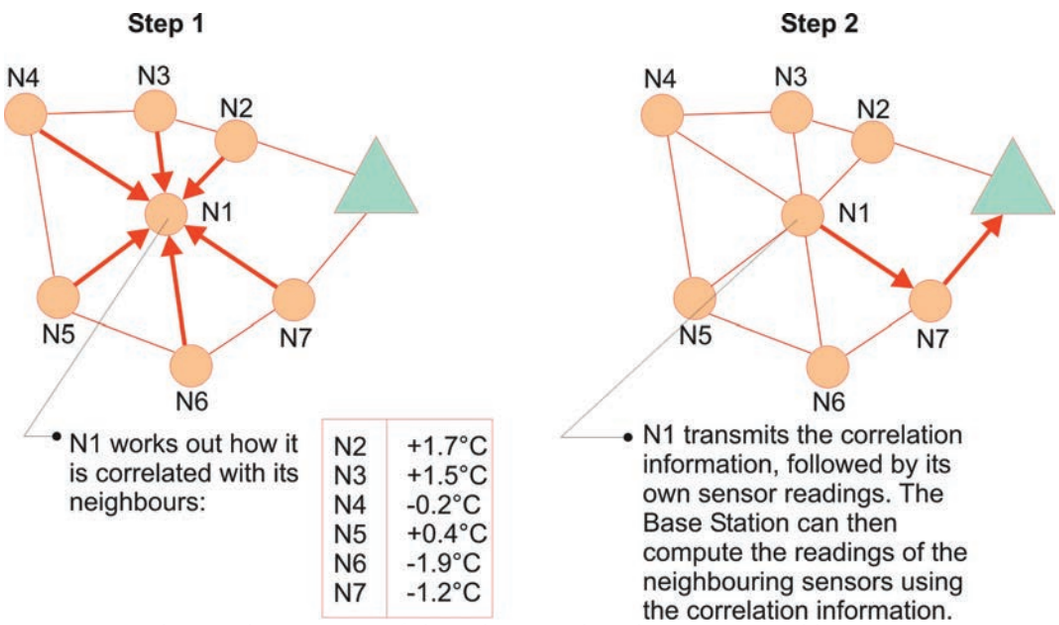


Figure 5: Reducing the amount of data that needs to be transmitted by taking advantage of spatial correlations of sensor readings

in order to ensure that the network continues to operate properly even with a dynamic network topology.

As we mentioned earlier, our algorithm does not only reduce energy consumption by reducing the operation of the transceiver by minimising the amount of data that needs to be transmitted, but also decreases the number of sensor sampling operations. The environmental parameters that we monitor do not always fluctuate very rapidly. However, there may be certain periods when such fluctuations occur. We take advantage of this pattern by reducing the sampling rates of sensors when sensor readings change gradually (and can be predicted fairly accurately) and increase the sampling rate at other times. Our algorithm also uses a distributed mechanism to "wake up" neighbouring sensors if a particular sensor detects a sudden spike so as not to miss out on any unusual events.

A large-scale sensor network of around 100 nodes is currently being tested around the campus of AIMS and also in the waters around the field operations jetty at Cape Ferguson to fix both software bugs to guarantee that communication is carried out reliably and also to ensure that the hardware (e.g. weather proof canister) is able to withstand the harsh climate that can be experienced out in the open sea. Figure 6 is an extract from the preliminary sensor readings that have been streaming in so far. The initial large scale deployment on the GBR has been planned for the later part of this year. ■

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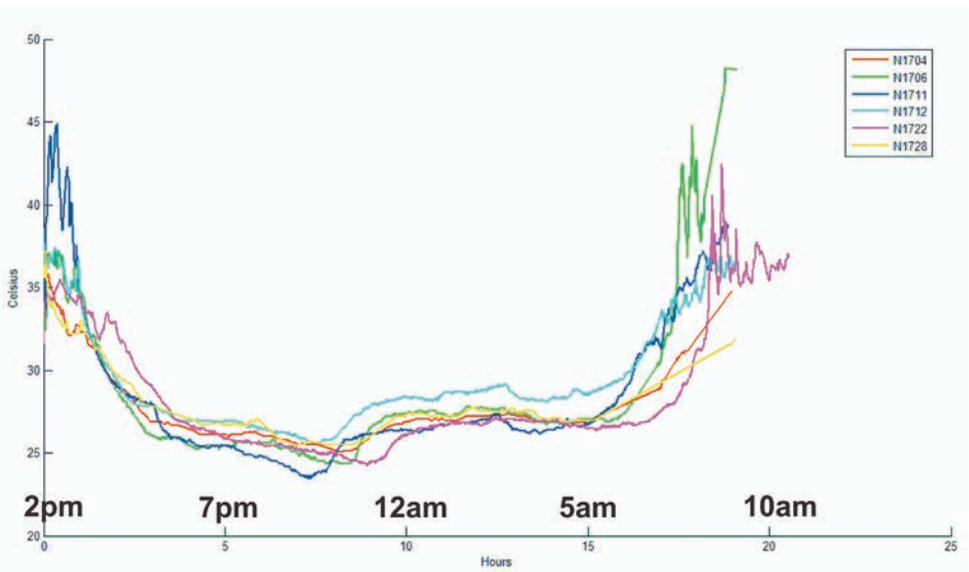
"The environmental parameters that we monitor do not always fluctuate very rapidly"



Figuur 6: Temperature readings streaming in from 6 sensor nodes deployed at the AIMS campus

Wireless sensor networks (WSN) are defined as a subclass of wireless ad hoc networks that enable monitoring, inspection and analysis of unknown, untested environments. A typical application type of WSN is to monitor an environment ranging from an agricultural .eld to a classified area for events that are of interest to the users. The characteristics of this kind of applications are quite different than the classical data collection type of applications. In this paper, we discuss the characteristics of event-based applications and present a classification and a survey of the existing applications for WSN.

Classification and Lifetime Analysis

of Event-Based Apllications for Wireless Sensor Networks

Introduction

Wireless Sensor Networks (WSN) [4], is an evolving technology that is the fundament of various ubiquitous applications. WSN is embedded into the real world and enables monitoring, inspection and analysis of unknown, untested environments with battery operated, tiny sensor devices. Sensor nodes are designed to collect sensor data about the context and to transmit the readings by wireless communication.

Basically there are two types of typical applications for WSN: data-collection and event-detection. Data-collection type of applications require periodic messaging to report the measurements. On the other hand, event-detection type of applications require reporting when an event occurs. In the literature, data-collection type of applications have been deeply investigated. In contrast, fewer ideas for power-efficient event detection sensing systems have been proposed [8]. We investigate the characteristics of event-detection applications.

Usually, the events are rare. Yet when an event occurs, a large burst of packets is often generated that needs to be transported reliably and usually in real-time to a base station [19]. For example, a surveillance system needs to alert authorities of an intruder within a few seconds of detection. Similarly, a fire-fighter may rely on timely temperature updates to remain aware of current fire conditions.

The large number of packets generated within a short period leads to high degree of channel contention and thus a high probability of packet collision. The situation gets worse by the fact that the probability of packet collision increases due to the dense neighborhood in a dense deployment.

To summarize; reliable event detection, managing high data rate, minimizing latency (due to real time characteristics), maximizing accuracy, managing densely deployment are the important characteristics of event-based WSN.

Power management is a major factor to achieve long-term operation in battery-operated WSN. Power management is much more critical in event-detection type of applications since the network has to be always-on to detect random events.

In this overview, we present a survey and classification of the typical event-detection type of applications. The reader can refer to [5] and [7] for different WSN application scenarios.

Event Based Applications - Detection of Abnormal Conditions

We classify the applications according to the context of operation.

Military Applications

Military applications use WSN for information collection, enemy tracking, battlefield surveillance, target tracking and classification. We give examples of WSN Military applications:

- **Target tracking/classification** [11]: Target (enemy) classification and tracking is one of the key battlefield tactical applications. classification algorithms use, for instance, input data that come from seismic and acoustic signal sensing. Sensor networks can be incorporated into guidance systems of the intelligent ammunition.
- **Chemical (nuclear, biological) attack detection** [4]: In chemical and biological warfare, being close to ground zero is important for timely and accurate detection of the agents. Sensor networks can be used to detect foreign chemical agents in the air and the water. They can help to identify the type, concentration, and location of pollutants.

- **Counter-sniper detection** [16]: Detecting and accurately locating shooters has been an elusive goal of armed forces and law enforcement agencies for a long time now. An ad-hoc WSN-based system is presented that detects and accurately locates shooters even in urban environments. The system consists of a large number of cheap sensors communicating through an ad-hoc wireless network, thus it is capable of tolerating multiple sensor failures, provides good coverage and high accuracy, and is capable of overcoming multipath effects. Explosive substance detection can be a sub-application of this class.

- **Submarine detection** [12]: In military context, submarine detection is an example of the target short-term time-critical aquatic exploration applications. In the face of state-of-art stealthy technologies, the acoustic signature of a modern submarine can only be identified within a very short range. Compared to remote sensing technology that has limited accuracy and robustness, a self-configured sensor mesh can identify an enemys submarine with very high probability since every individual sensor is capable of submarine detection, and moreover, the detection can be reinforced by multiple observations.

Surveillance Applications

Surveillance applications consider the problem of tracking unexpected conditions/situations by a WSN.

- **Border protection / Intruder Detection** [6]: WSNs can be used at border surveillance applications. The application ExScal is developed for the detection & classification of multiple intruder types (civilian, soldier, vehicle, etc.). This would be ideal for protecting an area that is too vast to be patrolled by human guards such as a national border.

- **Coal mine surveillance** [9]: Environment monitoring in underground tunnels (which are usually long and narrow, with lengths of tens of kilometers and widths of several meters) has been a crucial task to ensure safe working conditions in coal mines where many environmental factors, including the amount of gas, water, and dust, need be monitored and early warning systems about abnormal conditions can be developed.

- **Detection of abnormal animal behavior** [15]: Managing farms, particularly large-scale extensive farming systems, is hindered by lack of data and increasing shortage of labour. WSNs can be used to detect anomalies in the animal behavior such as the sickness or being poisoned, etc.

- **Human detection** [10]: CodeBlue is a new architecture, that allows wireless monitoring and tracking of patients and first responders in a disaster scenario such as an earthquake.

Disaster Relief Applications

Disaster relief applications use WSN as an early-warning system for disaster scenarios such as fires, floods, earthquakes, etc.

- **Forest fire detection** [18]: The forest fire can be a fatal threat in the world. Satellite based monitoring is a popular method to detect forest fire now. But the long scan period and low resolution of satellites restricts the effectiveness of the satellite-based forest fire detection. Moreover, satellites usually cannot forecast forest fires before the fire is spread uncontrollable. Real-time forest fire detection methods can be useful by using WSN. The goal is to detect and predict forest fire promptly and accurately in order to minimize the loss of forests, wild animals, and people in the forest fire.

- **Flood detection** [2]: In developing countries, warning communities of an incoming flood is an expensive proposal given their limited resources. The equipment necessary for early warning flood systems is expensive and centralized to support flood detection schemes that are computationally complex. Flood Early Warning System project explores new techniques for distributing the computation of flood detection within a WSN, grounding the research in reality through the design and installation of an early warning system for flooding in a developing country.

- **Volcano explosion monitoring** [17]: WSN can potentially advance the pursuit of geophysical studies of volcanic activity. WSN can greatly assist the geophysics community. The increased scale promised by lighter, faster-to-deploy equipment will help address scientific questions beyond current equipment's practical reach. Today's typical volcanic data-collection station consists of a group of bulky, heavy, power-hungry components that are difficult to move and require car batteries for power. Remote deployments often require vehicle or helicopter assistance for equipment installation and maintenance.

"The forest fire can be a fatal threat in the world"

- **Monitoring toxic substances in rural areas** [14]: The presence of arsenic in groundwater has led to the largest environmental poisoning in history; tens of millions of people in the Ganges Delta continue to drink groundwater that is dangerously contaminated with arsenic. In Bangladesh alone, if consumption of contaminated water

continues, the prevalence of arsenicosis and skin cancer will be approximately 2,000,000 and 100,000 cases per year, respectively, and the incidence of death from cancer induced by arsenic will be approximately 3,000 cases per year. A current working hypothesis is that the influx of dissolved arsenic into the ground water is greatly enhanced where irrigation for rice cultivation provides the primary source of aquifer recharge. To aid in validating this researchers undertake a rapid deployment of a WSN in a rice paddy in Bangladesh in January of 2006.

Distributed Water Quality Monitoring is another type of application. Since in many parts of Europe, river water is a major source of drinking water, treatment plant operators are faced with the more and more difficult task of determining water quality and deciding whether to use the available resources or not. Large amounts of data from sensors can be analyzed online and actions can be taken accordingly [3].

- **Hazardous substance detection (gas, oil, etc)** [13]: Deploying large numbers of sensors has recently been receiving a lot of attention for detection of hazardous biological or chemical substances in public buildings, airports, shallow water harbors and agricultural fields, etc. for instance, WSN can be used to monitor an oil pipeline to detect the leakages [1]. ■

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ADVERTENTIE

Sensor nodes can autonomously form ad-hoc groups based on their common context. We propose a solution for grouping sensor nodes attached on the same vehicles on wheels. The nodes periodically receive the movement data from their neighbours and calculate the correlation coefficients over a time history. A high correlation coefficient implies that the nodes are moving together. We demonstrate the algorithm using two types of movement sensors: tilt switches and MEMS accelerometers. We place the nodes on two wirelessly controlled toy cars, and we observe in realtime the group membership via the LED colours of the nodes. In addition, a graphical user interface running on the base station shows the movement signals over a recent time history, the latest sampled data, the correlation between each two nodes and the group membership.

Online Movement Correlation of Wireless Sensor Nodes

Introduction

Smart sensor nodes can become aware of being together by observing that they share a common context [5], such as the movement pattern. This paper describes the demonstration of the online correlation of movement data presented in [6], which was accepted for publication in Pervasive 2007. A large range of applications can benefit from this solution: sports and entertainment (people hiking or skiing together), healthcare (body area networks), and transport and logistics (smart vehicles carrying smart goods).

In this paper, we are interested in two specific problems derived from the latter scenario, which can be solved by achieving movement-based group awareness:

- Sensor nodes attached to goods carried in rolling containers (also called RTIs) can group together and discover/signal order picking errors.
- Sensor nodes attached to RTIs loaded in transportation trailers can group together and prevent delivery errors.

With respect to this scenario, we focus on the correlation of sensor nodes which are attached to vehicles on wheels. The sensor nodes acquire the movement information from tilt switches or accelerometers and periodically transmit the sampled data to the neighbours. When receiving the movement data from one neighbour, a sensor node calculates the correlation coefficient between its own sampled data and the received data, which represents a confidence value that the two sensor nodes are moving together.

The demonstration of our prototype system consists of two wirelessly-controlled toy-cars outfitted with sensor nodes, which organize in two groups, depending on the car they are attached to. The decision of the nodes is shown both locally, by means of the LED colours, and on the base station, through a graphical interface.

Hardware

We use the Ambient µNode 2.0 platform [1], with the low-power MSP430F1611 microcontroller from Texas Instruments. The microcontroller is equipped with 48kB of FLASH memory and 10kB of RAM. The radio transceiver on the µNodes operates in the 433/868/915 MHz ISM band and has a data rate of maximum 100 kbps. We use AmbientRT [4], a multi-tasking real-time operating system.

The sensor nodes acquire the movement data either from tilt switches or from MEMS accelerometers. In the first case, we use the the ASSEMTECH CW1300-1 tilt switch [2]. The price is below 2 EUR and the typical power consumption is approximately 2µW. The movement data is given by the number of contacts made by the switch ball per time unit, as the node is moving. The second solution uses the three-axis LIS3LV02DQ accelerometer from STMicroelectronics [7], with the price range around 15 USD. The typical power consumption is around 2mW. We operate the accelerometer in the ±2g scale and we retrieve the data on the three-axis through the I2C interface. The correlation algorithm uses the magnitude of the acceleration vector for all three axis x, y and z, which is the same in any frame of reference, no matter of the alignment and orientation.

Software

We implement our proposed correlation algorithm [6] on sensor nodes. The algorithm updates the correlation coefficient based on the movement data received from neighbours and the most recent local data. Implicit synchronization is therefore achieved, which is essential for a correct evaluation of the correlation. The algorithm operates on a circular buffer corresponding to approximately 16s time history. The execution time measured on the µNodes is in the range of 6ms.

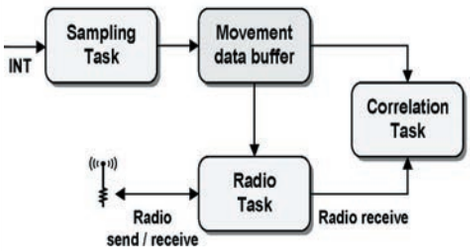

Figure 1: Implementation of the correlation algorithm

Figure 1 shows the general software architecture. AmbientRT operating system [4] allows to modularize the code into tasks that communicate among themselves through publish/subscribe mechanisms. The Sampling task is triggered by an interrupt (data ready to read on the I2C interface in the case of accelerometers, or ball contact in the case of tilt switches, respectively). The sampled data is stored in the circular data buffer, from where the Radio task periodically broadcasts the most recent sequence to the local neighbours. For regulating the access to the wireless medium, we use LMAC [3], an energy-efficient TDMA-based protocol designed for wireless sensor networks. When data is received from a neighbour, the Correlation task is triggered and the local correlation coefficient is updated accordingly.

Demonstration

The demonstration shows how the sensor nodes group based on movement information. We use four sensors nodes with tilt switches and four sensor nodes with accelerometers. During a demonstration, only four sensor nodes of the same type are active. The nodes are placed on two wirelessly controlled toy cars, as shown in Figure 3. The nodes convey their grouping decision by using different LED colours. In addition, a gateway node collects the correlation coefficients periodically broadcast by each moving node, together with the movement data, and logs them to the base station through a standard RS-232 interface. The base station provides a graphical user interface (see Figure 2), which shows the movement signals over a recent time history, the latest sampled data, the correlation coefficients between each two nodes and the group membership.

Figure 2 displays a situation where the nodes 1 and 2 are part of the same group, being attached to the same car, while the nodes 3 and 4, which are on the other car, form a different group.

Conclusions

This paper demonstrates an autonomous way of interaction between sensor nodes that can establish groups based on their common movement context. The proposed solution can be implemented on resource-constrained hardware, aiming thus at a low price range that would make it feasible in real world applications, such as transport and logistics. Initial experiments with our system prototype show reliable distinction between ensemble and separate movement, as well as robustness to constructive differences of sensors and to occasional packet loss. For future work, we plan to extend our solution to a larger-scale, multihop network, and fuse information from multiple types of sensors in order to improve the decision reliability. ■

Mihai Marin-Perianu,
Raluca Marin-Perianu,
Paul Havinga,
Hans Scholten

"The algorithm operates on a circular buffer corresponding to approximately 16s time history"

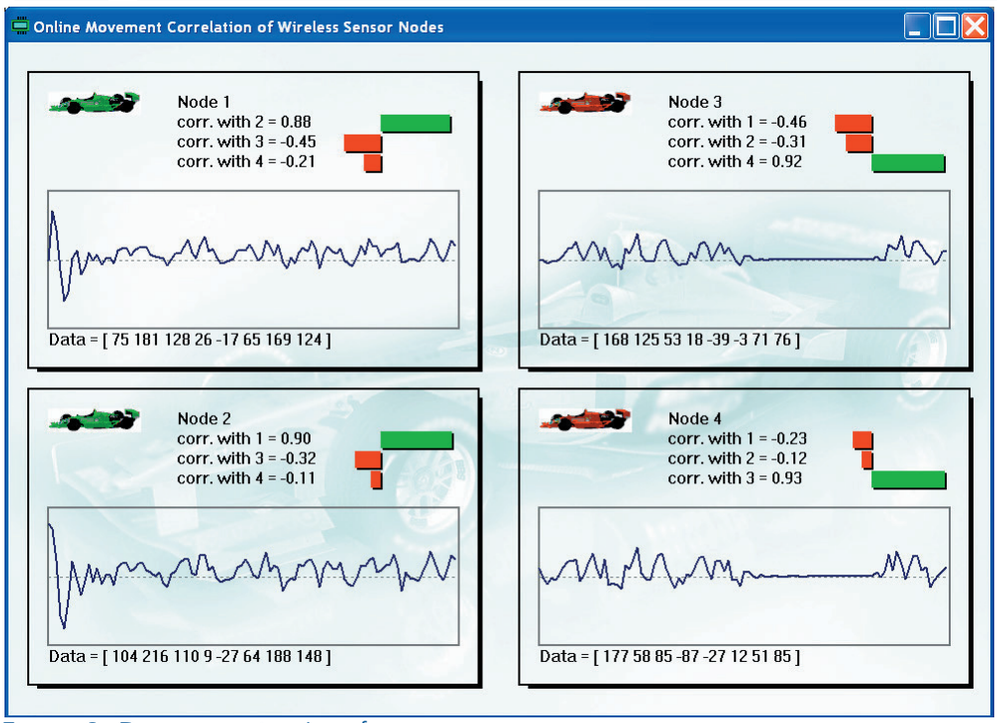

Figure 2: Demonstration Interface

Figure 3: Two sensor nodes with accelerometers attached to a wirelessly controlled toy car

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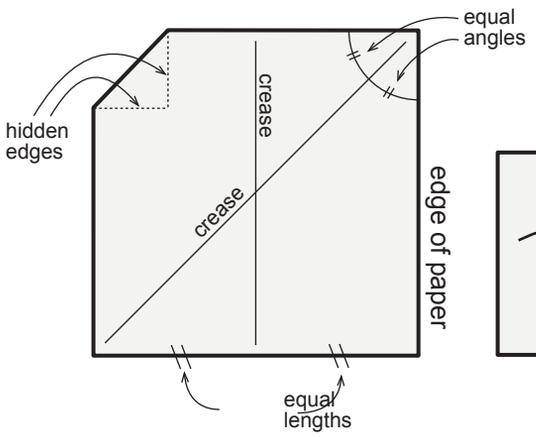
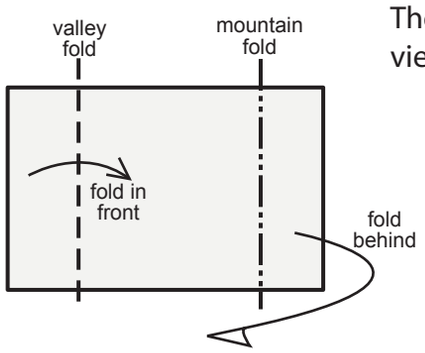
"We use four sensor nodes with tilt switches and four sensor nodes with accelerometers"

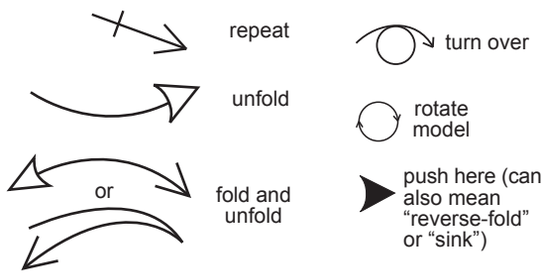
Origami folding instructions

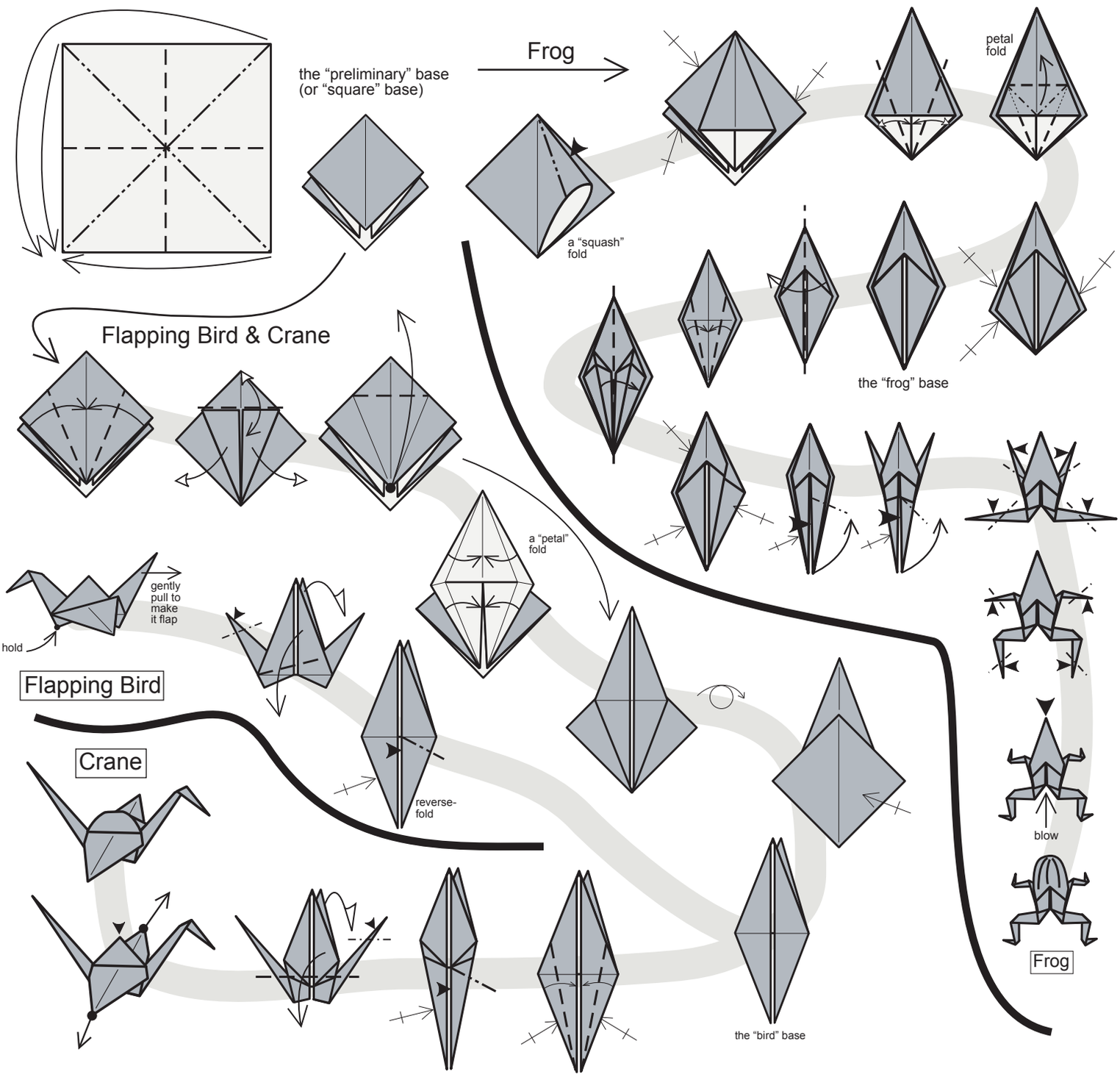
OrigAmi is named after the ancient Japanese art of paper folding. On this page we show you how to fold three of the traditional models.

The top part of this page contains a brief overview of the symbols and folding techniques used.









In future Ambient Intelligence (AmI) environments we assume intelligence embedded in the environment, its objects (furniture, mobile robots) and its virtual, sometimes visualized agents (virtual humans). These environments support the human inhabitants or visitors of these environments in their activities and interactions by perceiving them through their sensors (proximity sensors, cameras, microphones, etc.). Support can be reactive, but also and more importantly, pro-active, anticipating the needs of the inhabitants and visitors.

Non-verbal and Bodily Interaction
in Ambient Entertainment

Health, recreation, sports and playing games are among these needs. Sensors in these environments can detect and interpret bodily activity and can give multimedia feedback to invite, stimulate, guide and advise on bodily activity. Rather than aiming at improving user task efficiency, in the environments we investigate the aim is to improve physical and mental health (well-being) through exercise and through play. Exercises can be done in order to improve fitness, to prevent certain injuries (e.g. RSI), or to recover from an accident (e.g. physiotherapy exercises). Other exercises may aim at improving certain capabilities related to a profession (ballet, etc.), some kind of recreation (juggling, etc.), or sports (fencing, etc.). Fun, just fun, achieved from interaction (e.g. dancing or physical gaming) can be another aim of such environments.

In this paper we look at our research on bodily and gestural interaction with environments equipped with some simple sensors (cameras, microphones, dance pads), some application-dependent intelligence (allowing reactive and pro-active activity), and an embodied virtual agent employed in the display of reactive and pro-active activity. The activities we look at are dance movements (both from a virtual and a human dancer), music conducting (a virtual conductor conducting human musicians) and fitness, aerobics or physiotherapy exercises (to be performed by a human trainee or patient and to monitored and demonstrated by a virtual trainer).

Bodily Interaction: Entertainment, Health, and Others

Health, entertainment, sports, and leisure applications using information and communication technology often require and encourage physical body movements and often applications are designed for that reason. In our research we look at bodily and gestural interaction with game and leisure environments that are equipped with sensors (cameras, microphones, touch, and proximity sensors) and application-dependent intelligence (allowing reactive and proactive activity). Interpretation of the bodily interaction, requiring domain-dependent artificial intelligence, needs to be done by the environment and the agents that maintain the interaction with the human partner. In the display of reactive and pro-active activity embodied virtual agents play an important role. Virtual agents can play the role of teacher, coach, partner or buddy. One underlying assumption is that emphasis on activities in which the experience rather than the result will guide the design of social and intelligent systems that will become part of ambient intelligence home environments [2].

Inviting and Maintaining Interaction by Virtual Humans

Three applications have been designed in which our ideas about nonverbal and bodily interaction have been implemented. The implementations are available, but they are certainly not final. We will have a look at a virtual dancer that invites a visitor to her environment to dance with her, a conductor that guides musicians in its environment to play according the score designed by a composer, and a virtual trainer (e.g. in the role of fitness trainer or physiotherapist) that knows about exercises that need to be performed by a user or patient. In all these applications there is a continuous interaction between embodied agent and its human partner. Moreover, rather than have the more traditional verbal interaction supported by nonverbal communication, here the main interaction that takes place is nonverbal, and speech and language, when present at all, take the supporting role.

A Virtual Dancer

Our Virtual Dancer [3] is an interactive dancing agent that dances together with the user to the beat

of the music. The dancer adapts its performance to whatever the human user is doing. The moves of the virtual dancer, to be chosen from a database obtained from motion-capturing, are aligned to the beats of the music. These beats are detected real-time. The system observes the movements of the human dancer using computer vision software. The system extracts global characteristics about the movements of the human dancer, such how much (s)he moves around or how much (s)he waves with the arms. These characteristics are used to select moves from the database that are in some way "appropriate" to the dancing style of the human dancer. Finally, there is a dance pad that registers feet activity. By alternating patterns of following the user with taking the lead with new moves, the system attempts to achieve a mutual dancing interaction where both human and virtual dancer influence each other. Finding the appropriate nonverbal interaction patterns that allow us to have a system that establishes rapport with its visitors is one of the longer term issues that is being addressed in this research.

A Virtual Conductor

We have designed and implemented a virtual conductor [1] that is capable of leading, and reacting to, live musicians in real time. The conductor possesses knowledge of the music to be conducted, and it is able to translate this knowledge to gestures and to produce these gestures. The conductor extracts features from the music and reacts to them, based on information of the knowledge of the score. The reactions are tailored to elicit the desired response from the musicians.

Clearly, if an ensemble is playing too slow or too fast, a (human) conductor should lead them back to the correct tempo. She can choose to lead strictly or more leniently, but completely ignoring the musicians' tempo and conducting like a metronome set at the right tempo will not work. A conductor must incorporate some sense of the actual tempo at which the musicians play in her conducting, or else she will lose control. If the musicians play too slowly, the virtual conductor will conduct a little bit faster than they are playing. When the musicians follow him, he will conduct faster yet, till the correct tempo is reached again.

The input of the virtual conductor consists of the audio from the human musicians. From this input volume and tempo are detected. These features are evaluated against the original score (currently stored in MIDI) to determine the conducting style (lead, follow, dynamic indications, required corrective feedback to musicians, etc.) and then the appropriate conducting movements of the virtual conductor are generated. Computer vision has not yet been added to the system. That is, musicians can only interact with the conductor through their music. In a future implementation we can look at the possibility to have the conducting behavior directed to (the location of) one or more particular instruments and their players.

A Virtual Trainer

A Virtual Trainer is a virtual human capable of presenting physical exercises that are to be performed by a user, monitoring the user's performance and providing feedback accordingly at different levels. Our virtual trainer [4] fulfills most of the functions of a real trainer: not only performs the exercises to be followed, provides professionally and psychologically sound, human-like coaching. Depending on the motivation and the application context, the exercises may be general ones of fitness to improve the user's physical condition, special exercises to be performed from time to time during work to prevent for example RSI, or physiotherapy exercises with medical indications.

Currently, the trainer is in its design phase, but parts of its intended behavior are already implemented. In the design the focus is on the reactivity of the trainer, manifested in natural language comments on readjusting the tempo, pointing out mistakes or rescheduling the exercises. When choosing how to react, the static and dynamic characteristics of the user and the objectives to be achieved are taken into account, and evaluated with respect to biomechanical knowledge and psychological considerations of real experts. Hence if the user is just slowing down, the trainer will urge him in a friendly

"Finally, there is a dance pad that registers feet activity"

way to keep up with the tempo, and acknowledge with cheerful feedback good performance and introduce small talk every now and then to keep the user motivated.

Aligning Interaction with Goals and Events

In Figure 1 we have illustrated our three applications. In our applications there is a strong alignment or integration to external channels or events over which our embodied agents and the other partners in the interaction hardly have control. For example, whatever the bodily and nonverbal interaction is that takes place between virtual dancer and human dancer, the virtual dancer is programmed to follow the music and the human dancer is assumed to cooperate. Hence, their dance movements focus on the alignment of the dance behavior to the music. Similar observations can be made about the virtual conductor and the virtual therapist. The conductor has the score of the music as basis of his conducting behavior and its behavior aims at making the musicians follow the music. Our therapist has not yet been fully implemented, but one of the aims is to have its gestures, body movements, and verbal expressions aligned with music that supports the fitness, aerobics and physiotherapy exercises it offers to its human partners. It should be mentioned that similar kinds of alignment need to be observed in every application where we have rules and constraints on interaction, not only in dancing, conducting and training applications, but also in sports (tennis, fencing, chess) and in dialogues or conversations. ■

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"In the design the focus is on the reactivity of the trainer"

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In this paper we describe an intelligent embodied agent called the Virtual Guide (Accessible online via http://wwwhome.cs.utwente.nl/~hofs/dialogue) that can have a direction giving dialogue with visitors of a virtual environment, and present route descriptions using both language and gestures. The virtual environment in question is Virtual Music Centre (VMC), a 3D replica of the music theatre in Enschede developed at HMI. Currently the Virtual Guide is located at the reception desk of the VMC (see Figure 1), but she can be situated anywhere in the building.

The Virtual Guide

An Intelligent Agent Giving Directions in a Virtual Environment

The first part of most interactions between the Virtual Guide and the user consists of a natural language dialogue in which the dialogue management module tries to find out the user's intended destination. This may involve subdialogues, in which either the Guide or the user asks the other for clarification, and the resolution of anaphoric expressions (e.g., *How do I get there*?) The language of the Virtual Guide is Dutch, but for ease of reading all examples are given in English.

When the user's destination has been established, the language generation component of the Virtual Guide generates a natural language route description consisting of a sequence of segments that are mostly expressed as "point + direction" combinations [1], i.e. a turn direction combined with a description of the location where this turn is to be made, specified in terms of a landmark. For example, *You go left at the information sign*.

Finally, the gesture generation component extends the generated text with tags associating the words in the route description with appropriate gestures. The marked-up text is sent to the animation planner, which actually generates the required animations in synchronization with text-to-speech output, resulting in a multimodal route description.

Below, the three main components of the Virtual Guide are described in more detail.

Dialogue management

The Virtual Guide allows for multimodal dialogues, using text and speech as well as nonverbal input and output modalities. For instance, the user can use speech combined with mouse input by pointing at a 2D map of the VMC and asking *What is this?* In its turn, the Virtual Guide can

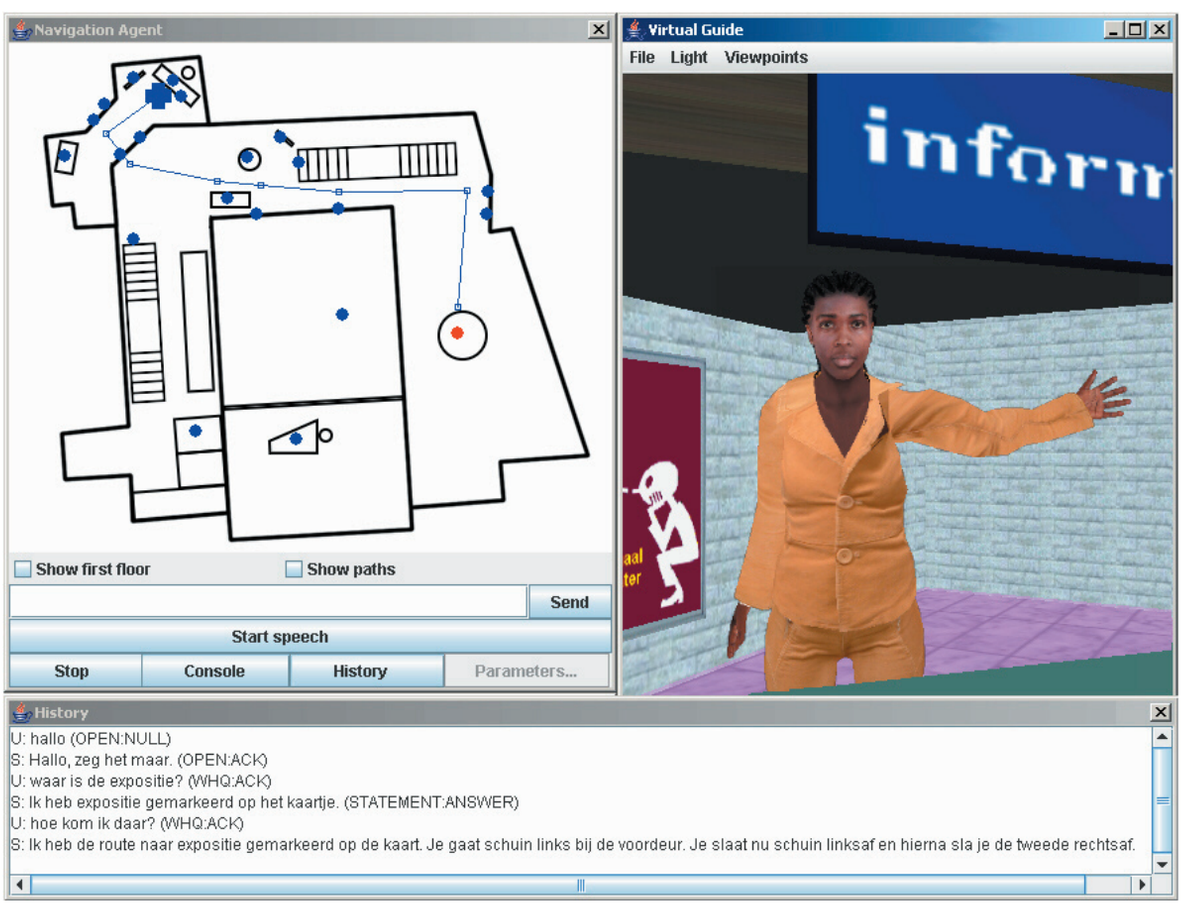

Figure 1: The Virtual Guide

produce speech accompanied with gestures and indicate locations and routes on the map. Here, we briefly discuss how the dialogue management module processes and responds to the user's utterances. More details can be found in [2].

The utterances of the user are parsed using a Dutch unification grammar, and the referring expressions they contain are bound to objects in the VMC. The following example illustrates various ways in which the user can refer to objects:

"The utterance *Could you take me there?* is classified as a request"

U1: (pointing at the coffee bar) *Is this the cloak room?*
S1: No, *that's the coffee bar. The cloak room is over there.*
U2: *Could you take me there?*

The user's first verbal reference in U1, *this*, is resolved by linking it to the coffee bar that the user is pointing at. The other reference, *the cloak room*, is resolved by matching the noun with the properties of the objects in the virtual environment. The anaphoric reference *there* in U2 has two possible antecedents: the coffee bar and cloak room, which have both been previously mentioned (by the user and the system). Of these two, the system chooses the cloak room as the most likely referent, because it was most recently mentioned. After the parses have been enhanced with information about the object(s) that the user referred to, they are sent to the dialogue act classifier, which uses rules and the dialogue history to associate them with one or more dialogue acts such as "statement" or "request". For example, the utterance *Could you take me there?* is classified as a request.

When the dialogue manager receives a dialogue act of the user, it chooses an appropriate reaction. For example, if the user has made a request, an appropriate system reaction would be to carry out the request. This new system action is put on top of an action stack that stores the system's planned actions. When it is the system's turn, it takes an action from the stack and executes it.

In addition to the action stack, the dialogue manager maintains a subdialogue stack (the stack of "questions under discussion") that keeps track of the current dialogue structure. Either the system or the user can take the initiative to start a new subdialogue by asking for clarification instead of directly answering a question. For example:

U1: How do I get to the cloak room?
S1: Which cloak room are you looking for?
U2: I meant the cloak room downstairs.
S2: You go left at the coffee bar, then...

The first user utterance is a question. As an appropriate response to this dialogue act, the dialogue manager finds a TellRoute action: telling the user the way to some destination. However, since the VMC has two cloak rooms, the required destination is not clear and the system starts a subdialogue by asking which of the two rooms is meant. This is added to the subdialogue stack as a new subdialogue, which is now on top of the stack whereas the main dialogue (containing U1) is at the bottom. The originally intended TellRoute action is put on the system's action stack, with a flag saying that it is not yet executable. Then the user chooses the downstairs cloak room. The dialogue act classifier decides that this is an answer to the question posed by the system in S1. This means an end to the current subdialogue, which is taken off the stack. The fusion agent now binds the noun phrase *the cloak room downstairs* to the correct object in the VMC, which is then filled in as the missing destination in the action currently on top of the action stack: the TellRoute action. With this the action is made executable, and the Virtual Guide starts explaining the route to the user.

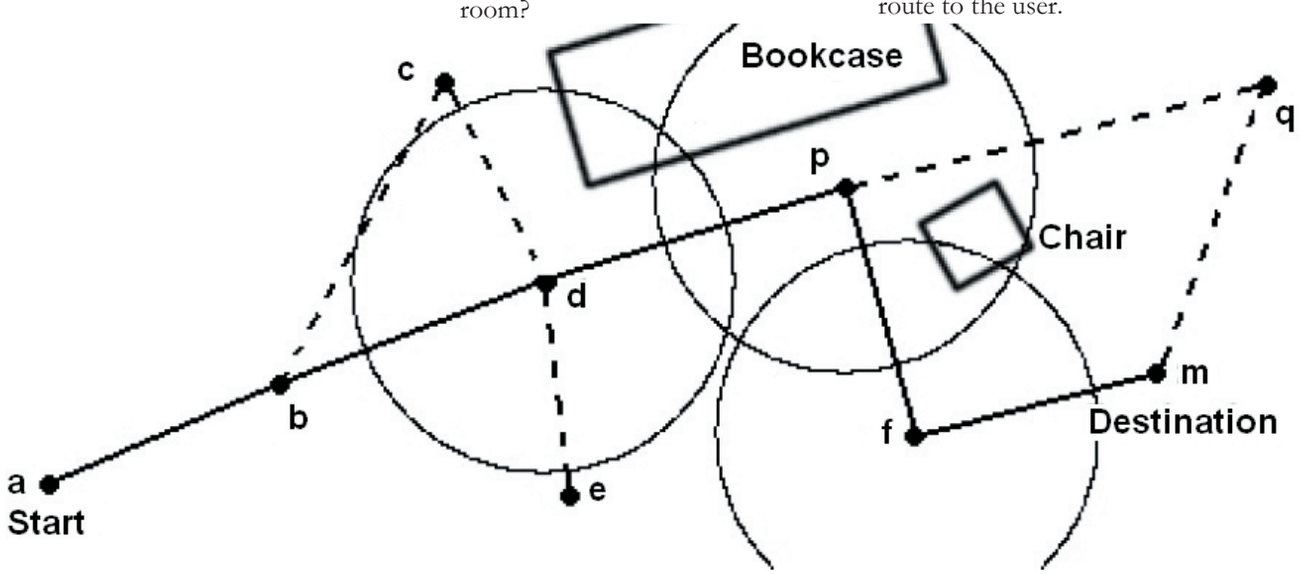

Figure 2: Example path with landmarks

Language generation

The Virtual Guide uses multiple output modalities in a route description: the route is projected on the map of the VMC (see Figure 1) and also described in words and gestures. First the system computes the shortest path from the starting point to the destination, based on a network of predefined paths in the virtual environment. An example path, consisting of a list of markers (*a, b, d, p, f, m*), is shown in Figure 2. Two connected markers (3D coordinates in the VMC) form a segment.

The first step of the language generation algorithm, which generates a text describing the route, is to calculate the angle between each pair of subsequent segments. Based on these angles, a turn direction is determined for each marker (straight ahead, sharp left, left, etc.) and added to the path. Multiple subsequent markers associated with the direction 'straight ahead' are filtered out. For the example path, this would happen to markers b and d, whereas markers p and f will be associated with a sharp right and left turn respectively.

The next step is to describe the locations where the turns are to be made in terms of landmarks, i.e., salient objects or other reference points. In buildings, typical landmarks include stairs, hallways and signs. The selection of potential landmarks by the Virtual Guide is done using a 'cylinder' vision. The path marker is used as an origin from which a cylinder-shaped area is drawn that simulates the user's viewpoint as he or she is standing at the location of the marker. All objects located within this cylinder can potentially be used as a landmark. The generator then has to decide which of these objects is best suited for use in the route description. This is done by reducing the set of potential landmarks to one based on their values for properties such as size, movability (immovable objects are more reliable landmarks than movable objects), colour and shape.

In Figure 2, the bookcase and the chair are potential landmarks for marker p, as they are the only objects within its cylinder. In this case the bookcase would be used as a landmark because of its size compared to the size of the chair. Marker f get the chair as its landmark, even though the chair is also near marker p. (Currently the route generator does not check if objects are closer to other markers than the one that needs to be described.) The information about the chosen landmarks is added to the path specification, which then looks as follows: *(a, <p, sharp right, (bookcase, large)>, <f, sharp left, (chair, green)>, m).*

The generation of the actual route description is done using Exemplars [3], a collection of predefined sentence templates associated with applicability conditions. They are organized in a specialization hierarchy, where more specialized templates can augment or override the more general ones they specialize. For example, some of the sentence templates used for the Virtual Guide only require a direction to be known, while others also need a landmark to refer to.

"The Virtual Guide uses multiple output modalities in a route description"

In order to achieve some variation within the generated route descriptions, at each level of the specialization hierarchy a number of equivalent exemplars is available, from which a random choice is made. For example, *Turn <direction> at <landmark> and At <landmark>, go <direction>*. This way, a first version of the route description is generated. In a second round, this initial description is revised by randomly combining some sentences using phrases such as then and after that in order to make the generated text more varied and coherent.

Gestures and animation

The generated text of the route description is extended with tags associating the words with different types of gestures to be made by the Virtual Guide. First a collection of possible gestures is created based on information about keywords in the sentence. For example, references to objects can be accompanied by (1) a pointing gesture to the absolute location of the object ('objective viewpoint'), (2) a pointing gesture to the location of the object relative to the position of a person who is walking the route ('subjective viewpoint'), (3) an iconic gesture, reflecting the shape of the object, and (4) a simple up-and-down 'beat' gesture, which has no inherent meaning but only adds emphasis to what is said. After the full route description has been generated, a selection from all possible gestures is made, based on a weighted randomization. The weights are currently determined by hand; a more realistic weighted system might be determined empirically based on the results of video analysis.

Finally, the gestures are animated and synchronized with the speech output by a modified version of the animation planner developed by [4]. The input for the planner is a route presentation script, specified in a multimodal mark-up language. Shown here is a fragment from a route description containing an objective viewpoint gesture:

```
<Channel name="Verbal">
<Verbal>Once upstairs, the door
to the balcony is to
your <SyncPoint id="P4"/>right
</Verbal>
</Channel>
<Channel name="Gesture">
<Deictic stroke="P4" location=
"(-1.0, 5.9, -30.0)"/>
</Channel>
```

This (simplified) example shows that one mark-up channel is reserved for verbal utterances and one for ges-

tures. In the verbal channel, synchronisation points are created as starting points for the gestures in the gesture channel. Utterances specified in the verbal channel are sent to a speech synthesizer which not only pronounces the text but also returns an estimation of the durations of the phonemes in the utterance. This information is used to synchronize the gestures with their associated words.

Discussion

The Virtual Guide has been implemented and is fully functional, but there is still much room for improvement. For example, the Guide does not keep track of which information it has already given to the user, and as a consequence, it will react in exactly the same way each time it is asked the same question. Also, when giving a route description, it cannot refer back to locations that are already known to the user. For the Virtual Guide to appear more intelligent, it needs to adapt more to the user. One step towards more adaptive dialogues that has already been taken is in terms of language use: recently a new version of the Virtual Guide has been developed that can adapt its linguistic style and level of politeness to that of the user [5]. However, this involves only the form of the system utterances, not their content.

When generating the route description, the potential landmarks selected by the Virtual Guide tend to be things like furniture and paintings. However, landmarks in route descriptions produced by human speakers more often correspond to structural parts of a building such as hallways and corridors, which are currently not available to the Guide's landmark selection algorithm. With respect to gesture generation, the current design where the verbal description is generated first and gestures are added later prevents the generation of utterances such as *Go left there*, where the verbal reference is dependent on an accompanying gesture for its interpretation. To achieve such complementary word and gesture combinations, a more integrated approach is necessary. Ideally, language and gesture generation should be fully intertwined.

So far, the Virtual Guide offers route directions in a virtual environment. An obvious step would be to also use it in a real environment, like NUMACK, an embodied agent that functions as a virtual guide for the Northwestern University campus [6]. This would pose various new challenges, in particular in the area of input analysis, such as determining the user's gaze direction using image processing techniques.

"There is still room for improvement"

Acknowledgements

This article is a shortened and adapted version of [7]. Rieks op den Akker developed the grammar, and Martin Bouman and Richard Korthuis created the language generation component of the Virtual Guide. The Virtual Guide was developed in the context of the NWO project ANGELICA. ■

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In recent years there is a growing popularity in the research of context aware applications. These applications provide a non intrusive interaction with a user. It is to be expected that these applications are going to make the transition from the research environment to the home environment. Cameras register your position, computers process all kinds of information about you and the amount of control you have to regulate this information influences your sense of privacy. But what makes a home a smart home? This paper researches the issues that are involved in making a home a smart home. A short user survey is used to see which context aware application type is the least intrusive and the most interesting.

Smart Homes

examining different context aware application types and privacy issues

INTRODUCTION

Context aware applications are going to appear in a home environment in the near future. But with these applications there are several issues that have to be addressed. This paper will focus on context aware applications in a home environment. The first part of the paper examines different aspects of the smart home. What kind of challenges are to be expected? And what are the different context aware application types? It then addresses one existing guideline with the privacy by design principle as a central point. Finally the different privacy threats are mentioned. Then a user survey is created and performed to find out the opinions of potential users about the different types of context aware applications.

SMART HOMES

A smart home is a setting in which people in their home environment are supported by computers who receive information from the environment and transform the information in appropriate actions. The applications are there to simplify the daily activities that take place in a residence. This could indeed be a very pleasant idea, because the present-day society is fast paced. But can a smart home be expected in the near future? Edwards and Grinter [EG01] talk about seven challenges that have to be addressed before these technologies can make the transition from the research environment to the home environment. These seven challenges are:

- The "accidental" smart home. When does a user know when his house makes the transition from a dumb to a smart environment?
- Impromptu Interoperability. How can smart technologies work together without having special requirements and implementations for every possible form of interconnecting between these different technologies?
- No system administrator. How can an individual exploit the full potential of the different types of context aware applications without having a degree in computer science?
- Designing for domestic use. How can technology be adapted so it is suited for the unstable home environment?
- Social implications. What are the broader effects of the technology?
- Reliability. Because consumers have different backgrounds with different expectations and necessities the technology should be reliable enough to adjust for all of these diverse requirements.
- Inference of presence of Ambiguity. How smart does a smart home need to be to achieve its goals.

In the next section context and possible types of context aware applications are explained.

CONTEXT AWARE APPLICATIONS

The challenge for an context aware application is capturing, accessing, and processing contextual data. For the home environment Meyer and Rakotonirainy [MR03, p2] say "people at home decide freely for themselves how they organize space and time, what activities they undertake, when, where, how often and who they involve". Because of the dynamic environment of a home the implementation of the context aware application becomes very complex. One has to look closely at the activities that take place in a home environment and see which activity can be augmented by a context aware application.

Context Information

Hong et al. [HCS05, p591] state "Contexts are typically locations, identities and states of people, groups, and computational and physical objects". But why is context important? Hong et al. [HCS05] give three reasons:

- Context reduces the input cost. Hong et al. [HCS05, p590] state "Explicit input from users is expensive. It interrupts the user's thoughts and slows down the speed of the interaction".

- Context may enhance an existing user routine. People's lives can be simplified by context aware applications if the applications can augment daily activities without any user input.

- Users benefit through context sharing. For example preferences between users and friends. Something that is interesting for you can be interesting for someone else. Applications could possibly share the context and provide a better service.

"But how can one develop a context aware application and keep your privacy protected?"

Application type selection

To give a good overview of what can be expected in the near future Brown et al. [BBL+00] list six possible types of context aware applications.

I. Proactive triggering is about an application with the capability to capture information of you or your surroundings. The application then processes the information and sees if an appropriate action can be performed.

II. Streamlining interactivity has the ability to simplify the communication between humans and computers. The application knows the user and as a result the user can ask a question much easier.

III. Memory for past events. The main aim here is to capture everyday activities and remembering them for later retrieval.

IV. Reminders for future contexts. The possibility to send a reminder if a certain context occurs.

V. Optimizing patterns of behavior. Here the application tries to see if there are any changes to be made in daily routines.

VI. Sharing experiences between persons with the same preferences.

But how can one develop a context aware application and keep your privacy protected? Next a privacy by design principle will be discussed and the different privacy threats are listed.

PRIVACY

Privacy guidelines

Langheinrich [Lan01] gives a privacy by design approach specifically aimed at a ubiquitous computing device. The guideline begins with notice. Notice is about keeping the individual informed about what the system is doing. The second principle is about choice and consent. Give the individual the opportunity to give his consent when there is the possibility that context information could be captured of him. Subsequently their anonymity, provide a way so that an individual can remain relatively anonymous. Then there is the proximity and locality principle. Locality is about keeping a boundary on the reach of the context aware application. Another principle is the insurance of adequate security to ensure that your private information is protected. Finally there is access and recourse, the ability to access a device and the choice to adjust the context aware technology so it behaves in acceptable manner. As a part of access and recourse there is the principle of collection and use limitation. This means that data is only used for a well defined purpose, only relevant data is collected and data is only stored for the time that it is useful. But what are the different privacy threats we are exposed to? Solove [Sol06] lists four:

- Information collection. Even if no information is revealed by data collection, the collection of data itself can be a harmful activity.

- Information processing, Solove [Sol06, p28] "Information processing refers to the use, storage and manipulation of data that has been collected."

- Information dissemination. The leak of personal data or threat of the spread of information.

- Invasion. Different from the first three threats because it does not always involve information. Examples are spam, junk mail, telemarketers. They enter unwillingly in your private domain.

To see if there is a relation to be found between the function of a certain context aware application and privacy issues a user survey was created. This will be discussed in the next section.

USER SURVEY

Design of the survey

For the design of the user survey the seven steps to a successful user survey were used [IS02]. The user survey was sent to about 85 people. After a week there were 40 replies. These were used to see if there is any relation between prevalence for a specific context aware application type and privacy concerns, also is there any difference between the answers for the different age groups and different educational backgrounds? The user survey was divided into three parts. The first part asked some demographic questions and questions related to privacy. The second part of the survey listed the different context aware applications types with some specific questions about

Activities [Sol03]	Grade of importance
Information Collection	7.45 out of 10
Information Processing	8.70 out of 10
Information Dissemination	9.38 out of 10
Invasion	9.63 out of 10

Table 1: Importance of privacy for the different activities

privacy and interest. The third and final part of the survey asked some general questions about the context aware applications.

First part

The first section began with some demographic questions about educational level, age, gender and how often they used their computer. Subsequently the privacy issues were addressed in which the first question was to give the different possible privacy threats (Table 1) a grade of importance. Finally a question was asked about the their concern about their privacy when personal data was used (Table 2). It was not possible to differentiate for age and educational level, because most of the people were between 20 and 30 years old and had a higher educational level. There were hardly any reactions from people above 30 or with a lower educational level (3 or less of the 40 recipients). Some of these individuals were asked why they didn't fill in the survey. Most of them responded that the different context aware application types were too difficult to understand. Thus there is a need for research in how to explain these different types of context aware applications. All of the individuals who filled in the survey used their computer more than four times a week and most of them used the computer every day. As seen in Table 1 the most important aspect about privacy is the protection of data against intrusion graded with a 9.63. Data collection is the least important aspect concerning privacy graded with only a 7.45. For the final question it can be said that most people are concerned about their privacy when person data is issued in some form (Table 2).

Second part

The second part of the questionnaire listed the six possible context aware application types from section 3.1 (Table 3 lists the different types). Each type was explained and augmented with a possible scenario to clarify the capabilities. The first three questions were about the interest in the application, privacy intrusion and willingness to give up private information. The final question asked if they would use such an application in their own home, see Table 3 for the results. Type II, streamlining interactivity, was the most interesting application with 65% of the persons answered that the type was interesting. Only 7.5% found type VI, sharing experiences, an interesting application. For Type II only 22.5% of the individuals found the application an intrusion of their privacy. For type VI this was 75% of the recipients. For Type II 40% was willing to give up some private information, for Type VI this was only 12.5%. Figure 1 lists the six different context aware application types and the individual scores for the three different questions. As seen in Figure 1 there is a relationship between the interest in the application and if the individual found the application intrusive. Also the interest of the application is related to the willingness to give up privacy sensitive information. For all the three questions type II and Type VI are the ones with the highest and the lowest score.

Third part

The final part of the survey contained some general questions about the different context aware application types. Also people were asked if there should be a safety control mark for these applications. Next the users opinion about the amount of control they wish to have was asked and subsequently if they are presented with a profile about which information is collected and used, would they then be willing to give up more information. The most interesting context aware application type is Type II, streamlining interactivity. But why did they find type II the most interesting? 92.5% of the individuals said it was because of the function of the context aware application type and not because it was the least intrusive one. Also 97.5% has the opinion that there has to be some sort of control mark to ensure your security. For a context aware application one would expect that such an application could make choices on its own without any user input. But from the survey it is seen that 70% of the individuals wants to setup the context aware technology without the context aware application making any choices for itself. 30% wishes the context aware technology could provide some different options for the user. And after setting up the context aware application nobody would like the application to make choices for itself to improve its own functional-

"Nobody would like the application to make choices for itself"

Privacy Concern	1 person = 2,5 %
Very Concerned	10%
Concerned	42.5%
Neutral	40%
Not Conserned	7.5%
Not at all concerned	0%

Table 2: Privacy concern

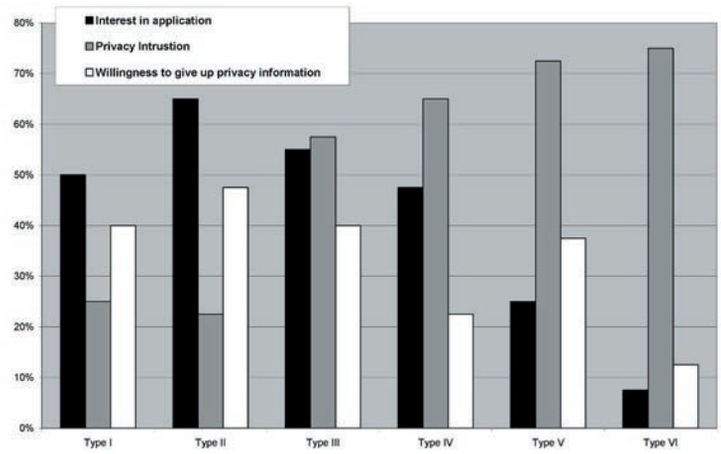

Figure 1: The different context aware application types

Type	Use in own home?
Type I: Proactive triggering	57.5%
Type II: Streamlining interactivity	67.5%
Type III: Memory for past events	35%
Type IV: Reminders for future context	37.5%
Type V: Optimizing patterns of behavior	30%
Type VI: Sharing experiences	15%

Table 3: Use in own home

ity. Subsequently it was asked if they are willing to give more personal information if they could see which information the context aware application has captured of you. 65% of the persons are willing to give more information if they can see which information the system has collected.

"Then people are willing to give up some private information to get the context aware application functioning"

CONCLUSION

The first four sections of the paper tried to give an introduction about the different aspects of the smart home. This led to the development of an user survey. The survey is used to see if the potential users had any opinions about privacy issues and the different context aware application types. In total there were 40 individuals who completed the survey. Most elderly people and people with a lower level of educational did not fill in the survey because they had difficulty understanding the different context aware application types. So there is a need for research in how to explain these different types of context aware applications to these individuals.

The section about the different context aware applications types of the survey shows that there is a relationship between the kind of application and the intrusiveness of the application. Type II (proactive triggering) is the most interesting and the least intrusive and Type VI (sharing experiences) is the least interesting and the most intrusive. Also the kind of context aware application type is related to the willingness to give up more private information. For Type II (the most interesting) they are willing to give up the most information. And type VI (the least interesting) has the most resistance to give up any private information. The results are shown in Figure 1.

The user survey shows that people are willing to give up more privacy sensitive information if the context aware applications provides the information it is collecting of the individual (for example a short user profile). Subsequently it is seen that although a context aware application should support individuals with their daily activities it should not make choices on its own in how to best support the individuals.

It is important to combine a privacy by design principle (for example the guideline from Langheinrich) with the possible privacy threats of data collection, processing, dissemination and invasion to protect the privacy of those individuals of which information is collected by the context aware application. Finally context aware applications will only have a future in a home environment if the application is interesting enough to augment your house with. Then people are willing to give some private information to get the context aware application functioning. ■

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Take away mouse and keyboard. Now, how do you interact with a computer? Especially one that has a display that is the size of an entire wall. One possibility is through gesture interfaces. Remember Minority Report? Cool stuff, but that was already five years ago.. So, what is already possible now and where is this all going? And what are the technical (computational) challenges of building these interfaces? Find out.

Human Media Interaction

Gesture interfaces

Minority Report

The most famous example of a gesture interface is perhaps the one in Minority Report, a movie from 2002. Actor Tom Cruise plays precrime agent John Anderton who tries to prevent an imminent murder from happening by searching a highly detailed vision from three so-called 'precogs'. The display that visualizes the vision, its analysis and added subject information is controlled through gesturing. Researchers from the Massachusetts Institute of Technology (MIT) participated in setting this scene up as technology advisors. Their contributions ensured that everything in the scene was believable, realistic and downright awesome. And you have to admit, the scene still looks very much so.

It was cool to just look at but in fact, the way this interaction was depicted has more than meets the eye, much more. It was properly based in science and research trends thanks to the technology advisors from MIT. The interface is controlled through a limited set of gestures, which is a good thing. You want to avoid cases in which a user has to learn a complex language or set of commands before he or she is capable of using this interface [3]. Consider, for example, a novice Windows user: 'look, that arrow on the screen moves when I touch this wired thing on my desk!' Gesture interfaces should be easy to both comprehend and work with.

The gesture language we see John use to issue commands is in part intuitive and in part awkward. We can probably agree that 'intuitive' entails that pointing at the display means selecting something and that moving something is done by subsequently grabbing and moving the object. But how do you perform more complex tasks? Which gesture (if such a gesture exists at all) is suited for correlating the selected engine component in your car design to similar components in other designs?

In the movie, each command is issued carefully by explicitly holding his hands still to indicate a gesture's start and stop in time. Although this is not intuitive, it is commonplace in prototyped laboratory gesture-based systems to prevent confusing the computerized interpretation of your commands [2]. This was seen in Minority Report as well where the system mistakenly interprets John shaking hands with a FBI investigator as the 'minimize all' command. I argue that such a system should be able to interpret your natural, unaltered gesturing correctly to have an intuitive interface; let the computer sort it out.

Perhaps most importantly, the interface in Minority Report is able to interpret gestures based on the context they are made in. Moving your hands apart as in, for example, 'the fish was this big', means both 'zoom in' and 'separate these two things' in the movie. How do you detect this context automatically? It is named Situational Awareness and it is topic of extensive research. Consider meetings in which automatic detection of the current discussion topic can provide additional relevant information to the participants [1]. Such situational awareness makes more complex gestures easier to understand for the system.

"In the recent years, great steps have been taken in gesture-based interfaces"

Why do I need a Gesture Interface?

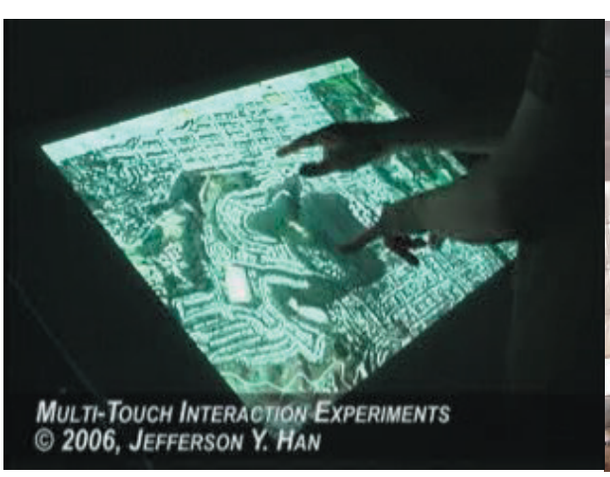
Consider a future smart environment in a hospital. Doctors can go to this room to discuss a particular patient. With emerging technologies such as microarrays [4] it will be possible to gain huge datasets that will predict this patient's response to a specific medicine, which might mean the difference between life and death. These datasets contain various views, varying from 3D cellular visualizations to scatter plots and workflow models [5]. These data are visualized on a large display, say 6x2m.

How do you control such large screens without having to worry about working the interface rather than working on the data directly? Gesture-based interaction targets the need for an intuitive interface that allows direct control over large sets of data. However, it is unlikely that such systems will replace the PC we all know and (dis)like. They will rather provide a more suitable means to immerse and captivate users who struggle with complex data and tasks.

Reality Today

What is possible today? In the recent years, great steps have been taken in gesture-based interfaces. I will discuss a few of these systems here. Perhaps the most familiar one is the famed iPod and its successors, the iPod Touch and iPhone. Other familiar systems include the Nintendo Wii, the Playstation EyeToy and PDAs. The first two are meant to be entertaining in use so they are especially comprehensible. These commercial products are based on rather simple, somewhat inaccurate principles and technologies because it is hard to make such a system robust in everyday life. This contrasts with high-end yet accurate motion capture systems that are used in movie animations such as famed Gollum.

Relating more to large displays such as the one in Minority Report, we have seen the now-famous movies from Jefferson Han and his multitouch tilted display [6]. The displays project infrared light through an acryl sheet, which diffuses from the glass through touch as a result of a process named Frustrated Total Internal Reflection (FITR). An infrared-sensitive camera behind the acryl sheet filters out the touch points which you can then start to analyze. Add a projector behind the acryl sheet and you have an interactive multitouch display that is sold by Han's company Perceptive Pixel. You can even build this display yourself with plentiful online tutorials available. The analysis of the detected touch points is a hard thing to



do accurately though. As an example challenge: how do you distinguish between fingers from two or more hands that are close together?

Microsoft has taken this surprisingly simple technology that originally comes from fingerprint scanners to develop a multitouch tabletop named the Microsoft Surface. They added infrared reflector patterns on the bottom of small objects such as cameras and mobile phones but also on non-digital objects such as wine glasses. Recognizing these unique reflector patterns means recognizing the device and possibly connecting to it wirelessly. Copy your photos from a camera to the tabletop by simply placing it on the table! Or see where the wine in your glass comes from in France.

The gesture interface in Minority Report is quite different from these devices though. The user does not have to touch a surface and appears to wave his hands at the display in mid-air. This class of gesture-interfaces needs to analyze an informative third dimension that is especially useful for interaction with 3D visualizations, for example, in car design. Also, touch screens have a challenge known as the 'reaching problem'. You simply cannot touch the entire area on a large wall-sized display. One solution is to use a sort of viewport which behaves very similar to a laptop's touchpad [7]. Clearly, there has to be a better solution.

A commercial example of a 'gesturing in mid-air' system is GoodPoint by Gesture Studios, a spin-off company of Minority Report's technology advisors from MIT. GoodPoint is an implementation of the Minority Report interface that is currently sold for presentation purposes. The systems use infrared cameras and marked gloves to detect, analyze and interpret the limited set gestures that its users can make. Other more complex gesture-based systems are mostly prototype systems for research [2].

Additional challenges have to be overcome for these systems though. Detection of the hands is hard in non-lab settings. Using either marked gloves and computer vision or tethered data gloves are the most common approaches but they are obtrusive and often inconvenient for the user [2]. Also, keeping track of the hands adds to this challenge because occlusion has to be dealt with. How do you recognize a hand that is occluded by another hand or object? Recognizing and interpreting these gestures deals with similar problems as those addressed for touch screens, with an added third dimension. Imagine that we do have a source of detailed gesturing information. We would then need to search for familiar patterns in the current stream of gesturing. How do we recognize a gesture while it is being made to prevent the system lagging behind your input? How do we deal with user dependent gesture styles? A simple Hidden Markov Model solution just does not cut it here.

"Those glowing lights on the gloves that John wears are somewhat impressive and cool"

Open Challenges in Gesture Interfaces

Those glowing lights on the gloves that John wears are somewhat impressive and cool. For a while anyway. But why wear gloves at all? They do indicate to the computer where your hands are but it is another of those things you would want to do without. The GoodPoint system uses those marked gloves for detection and the multitouch displays by Perceptive Pixel and Microsoft require their users to touch the display, making it smudgy in the process. The challenge remains to find an unobtrusive detection and tracking solution that provides the system with real-time, detailed and robust gesture descriptions. And then we still have the multi-user case.

Fatigue presents an additional challenge. It is implausible to be gesturing for a prolonged time. Touch screens have an advantage here because they provide some minor rest while working. Ideally, a gesture interface should allow both touching and gesturing in mid-air, perhaps with distinct interaction schemes in each case [3]. This topic has largely been avoided in the HCI community.

A gesture interface by itself will not be suited for entering large amounts of data into a computer, for example. Speech recognition would be ideal here. This and other sources of information are present for Minority Report-like interfaces but have to be tapped into as well. Also consider body pose and eye gazing. These three topics merit their own equal amount of research as does the topic of modality fusion that addresses how to combine these multiple sources of information [3].

An intuitive gesture language is a topic that has been addressed above. There is still no consensus over what works best [3]. Currently, I am looking into this topic in more detail together with a Master student, hoping to discover what gestures people make when given a specific task in controlling a Google Earth-like map application. It has been shown in earlier research that what we consider to be intuitive is based on metaphors. These metaphors often come from everyday life and the challenge will be to find metaphors that suit inter-

action tasks. As an example metaphor you only need to look at the Windows operating system where you delete files by sequentially selecting, dragging and dropping it in a trash can. You do the same in your kitchen. What would be good metaphors for the case in which you are deciding on a medical treatment for a hospitalized patient?

More information

Are you interested in gesture interfaces or an adjacent topic? It is possible to participate in, or carry out, group projects, Capita Selecta assignments or Master assignments! Look for more information on http://hmi.ewi.utwente.nl/project/BioRange or mail biorange@ewi.utwente.nl. ■

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"You do the same in your kitchen"

OrigAmi Program

10:00-10:30	Reception with coffee and tea		
10:30-10:45	Opening by the chairman of the day		
10:45-11:45	**Alejandro Jaimes** *"Augmented Multiparty Interaction: from Meeting recording to enhancing collaboration"*		
11:45-12:05	Coffee break		
12:05-12:50	**Marjan Grootveld** *"Location-based stories in education"*	**Robert Stegwee** *"RFID in Healthcare"*	**Maria Lijding** *"Smart Signs welcome you to smart surroundings"*
12:50-13:50	Lunch		
13:50-14:35	**Arjan Egges** *"Using Motion Capture for Character Animation"*	**Maarten Wegdam** *"Context-aware telemonitoring and tele-treatment"*	**Gijs Withagen** *"How innovative mobility solutions ease our lives and save the environment"*
14:45-15:30	*Workshop* *TBA*	**Egon van den Broek** *"Empathic Computing: The foundation for new A.I."*	**Milé Buurmijer** *"ICT on trains"*
15:30-15:50	Coffee break		
15:50-16:50	**Corien Prins** *"Do we want law to play a role in a smart world?"*		

Track Education & Entertainment

Ambient intelligence promises to integrate education and entertainment into the environment and augment your reality, making it more realistic and exciting than ever before. Will ambient intelligence transform gaming into a ubiquitous experience? Will we still watch films, or can we interactively change the story as we want it to be? Will learning be faster? And can education be more fun when it is set in an interactive environment? ■

Track Living & Care

A lot of attention in the field of ambient intelligence has been given to elderly care, but young people also worry about staying healthy and having a good lifestyle. People do not only search a healthier life in the hospitals, but also at home. Not only is a healthier lifestyle wanted, but also a more comfortable one. Can your home, the gyms and hospitals adopted to be more comfortable and healthier? It will be interesting to see how ambient intelligence can support this. ■

Track Work & Travel

Ambient intelligence can change the way we communicate, the way companies do business and how we do our jobs. Do we still have to go to work once we have ambient intelligence; can we start working when we're still on the road; or can everything be done from home? In what new ways will we be able to communicate? Can ambient intelligence get us safer and faster to our destinations? ■