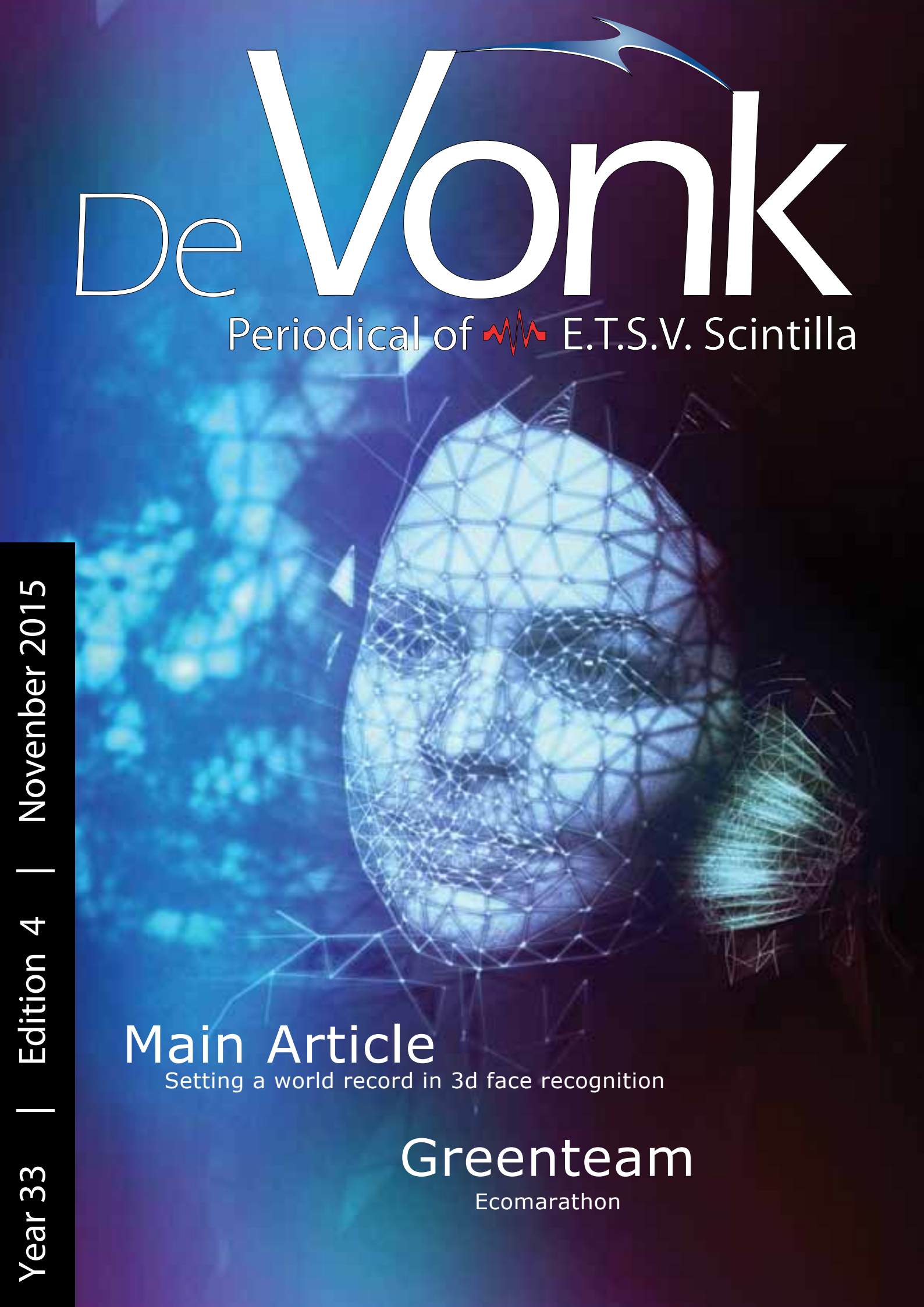
De Vonk

Periodical of E.T.S.V. Scintilla



Main Article

Setting a world record in 3d face recognition

Greenteam

Ecomarathon

Year 33 | Edition 4 | November 2015

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A new beginning.

Author: Jippe Rossen

As a person I always try to see the positive in things: when I have to get up early I say to myself: I have more hours to live consciously. When the battery of my phone is dead, I tell myself: I can cherish the beauty of the world around me. So following this line of reasoning I want to think the start of the study year 2015/2016 as a new beginning rather than the end of the board year of the 85th board.

However, as this is already the last edition of the Vonk for this study year, I cannot restrain myself from having a short recap of everything we went through last year! What to think of that magnificent Hamburger event hosted by the borrel in oktober? Or the Thea (ThaartEetAvond (Pie baking contest)) which was supervised by no one less than our own study advisor Thea? Or the 'On the Rocks' borrel were there were complaints at 10:30 pm by the IAPC that they could concentrate on their programming properly? Of course these are just a small selection that highlighted the past study year for me!

This however is also a time to look ahead. As part of the new beginning, great events are coming soon. I am not even talking about our 50th anniversary, but some major other changes lay ahead to things everyone considered to be stable and unchangeable. I will not spoil the surprise just yet, you will all experience that in due time.

I would like to conclude this last writing from the 85th board of Scintilla with this: to everyone who had a great year, may this next year be (with a slight stinging pain in my heart) even better! And to those who were less fortunate, may this study year be a new start with great successes and happiness!

Damen en heren, op de Koningin, op Scintilla!

Jippe Rossen
Vice-President
85th board of Scintilla

Wijnproefavond
donderdag 26 november
20:00, Abscint

SCALA's Kerstdiner
donderdag 17 december
19:00, Educafé

SKItilla 2016 Skireis
vrijdag 26 februari
18:00, Les Sybelles

Masthead

De Vonk

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Editorial team
Tim Broenink, Lynn Bruins, Pepijn Ekelmans, Guus Frijters, Mark van Holland, Bas Keet, Jippe Rossen, Ewoud Vissers.

Cover Artist
Robert Fennis

Print
Gildeprint, Enschede

Editorial office
E.T.S.V. Scintilla, University of Twente,
Postbus 217, 7500 AE Enschede,
0031 53 489 2810
0031 53 489 1068
vonk@scintilla.utwente.nl

Material
vonkkopij@scintilla.utwente.nl

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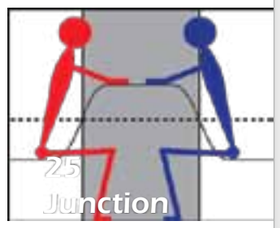
In the main article this edition, Luuk Spreeuwers talks about the university research of the SCS-group. The article will explain a lot about 3D facial recognition, one of the biggest researches the SCS-group works on. The article focusses on new and better ways to make the 3D recognition perfect, such as motion correction and improved registration.

Fieke talks again about SolarTeam and what it changed for her. The challenge that she went through, starting from building a wooden car, to the achievement of building a real car based on solar energy. Fieke gives a short explanation about the solar cells, and what surprised her when seeing the RED Engine.

In this article the SEM (Shell Eco Marathon) will be reviewed day by day. After a year of hard work and stress, which we could all follow every edition of the Vonk, finally the final challenge arrived. This day by day report will give you a good view of what happened and what they achieved after a long year of work.



In this junction Bert Molenkamp, professor of Computer Science in M5, talks about his experience in the working field. He also talks about his study, his student life, his home life and other things which are just nice or fun to know.

Editorial

A new beginning

The new academic year has started and so we continued working on the Vonk. The concentration can be better since we just started. One of the important things to do at a lay-out evening is to set up a good music play list, because lets be honest who can work in silence?
This year started with good intentions, I was going to keep up with the lectures and not fall behind, I was going to be very productive this year. While the colleges started these intentions started to fade away. 'The lustrum opening is just a one time event, I can study tomorrow', or 'it's been a while since I last played with my friends online' I would think, and before you know it you are as productive as you was in the end of last year.
While I'm trying to write something of interest here, that will be cleansed over by most readers anyways, there is a party going on downstairs, and people are playing board games in the Educafe. Then when I look around here just a hand full of people are working, or are taking a well deserved break to listen to the music which is playing. The further the evening progresses the les active we become, and the better the music becomes.
Now that the year has just started we want this edition sent to your doorsteps as soon as possible, so you will have something to read when taking a break from studying, or just when there is nothing better to do. Nobody can be busy studying all day long anyways.
So good luck to everyone and make this year one worth remembering for the years to come.

Mark van Holland

Educational updates

Author: Roel Mentink

The Twente educational model has been around for a couple years already, the implementation however has still not been completed. In a previous article I already explained about the new minor system in both modules nine and ten, so in this article I would like to explain what is scheduled for the second half of the third year. In addition to that I will tell a bit about some small changes in the second year.

During the second half of the third year there are two modules. The eleventh quartile will contain a design module and the twelfth module will contain the bachelor's assignment.

The Design module will be a big project that will bear some resemblance to the old B2-project. A group of students will have to work on a big project. Alongside this project, there will also be a couple of courses. There will be lectures about system design, design in a user- and social contact and signal processing. As explained later on in this article, most of the signal processing from module eight will be moved to module eleven. The requirement to join module eleven is that you need to have completed module three (Electronics) and either module six (Systems and Control) or module eight (Signal Processing and Communications). In addition to this, you need to have completed at least eight modules (including minor modules).

The twelfth module will contain the bachelor's assignment. This module is still being developed, but there are already some plans for this module. Basically the students will work on a big individual research project at one of our many research groups. There will probably also be several lectures about doing research and writing a thesis. There will also most likely be a final event for this module, where every student will give a presentation of some sort. This way, there will be no people that will have to work all summer long to finish their project. This module is most likely being taught twice a year; in the second and fourth quartile. Again, this module is still being developed, so everything is still subject to change.

Furthermore, there have been some changes in the module six (Systems and Control) and eight (Signal Processing and Communications), due to feedback from last year. A main complaint from last year was that the workload was insanely high in both of these modules. This year, around half of the dynamical systems part of module six will be removed from the module. Additionally, there will be no video-lectures anymore for the control engineering part. In module eight, most of the signal processing part will be moved to module eleven (the design module), reducing the work-load significantly. Finally, there are some new minor modules. These are join-in minors at other study's in quartile three or four. For a list of these minors, you can look at: https://www.utwente.nl/en/education/electives/minor/join-in-minors/join-in-minors-quartile-three-four/

If you have any questions regarding these changes, you can always walk into the Scintilla room and ask the board. Alternatively, you can ask Thea de Kluijver, our study advisor.

News for the electrical engineer

Author: Tim Broenink

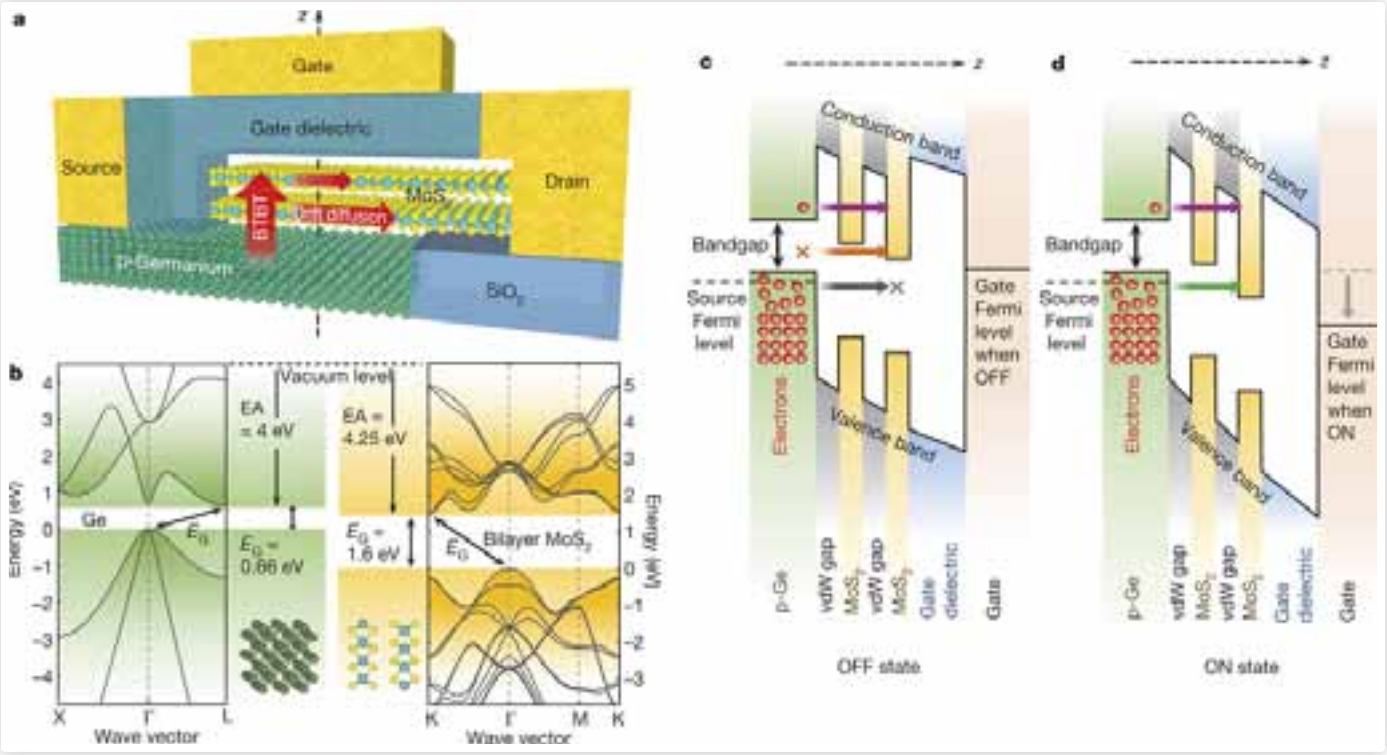
Flat transistor defies theoretical limit

A new TFET made with ultrathin MoS2 and p-type Germanium, developed by a team of researchers from the university of California and Rice, pushes the theoretical limits on FET technology. The FET uses tunneling to reduce voltage requirements and thus allow for faster electronics without increasing the power demands exponentially. The Tunneling-FET (TFET) works by covering the source with two thin layers of MoS2, which will then transport charge based on quantum tunneling. As the negative differential resistance associated with tunneling is also present in this configuration, this creates a very steep subthreshold slope, a property directly related to turn-on time, far below the theoretical limit.

Source: http://www.nature.com/nature/journal/v526/n7571/full/nature15387.html

3D vision from a single camera

Engineers from the Duke university of North Carolina have unlocked the potential of a single 2D camera to capture 3D images. This feat was made possible by a technique now employed in a lot of mobile cameras: optical image stabilization.
Normally a 3D image can be created by either taking a set of pictures from different perspectives, or by using different focal lengths from the same position. This can



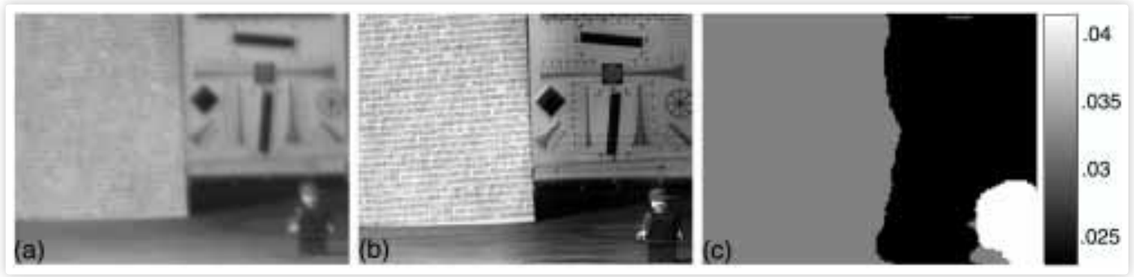


Figure 1:Experimental results. (a) Raw data captured by the prototype camera. (b) All-in-focus reconstructed image. (c) Reconstructed depth map with colors corresponding to the distances

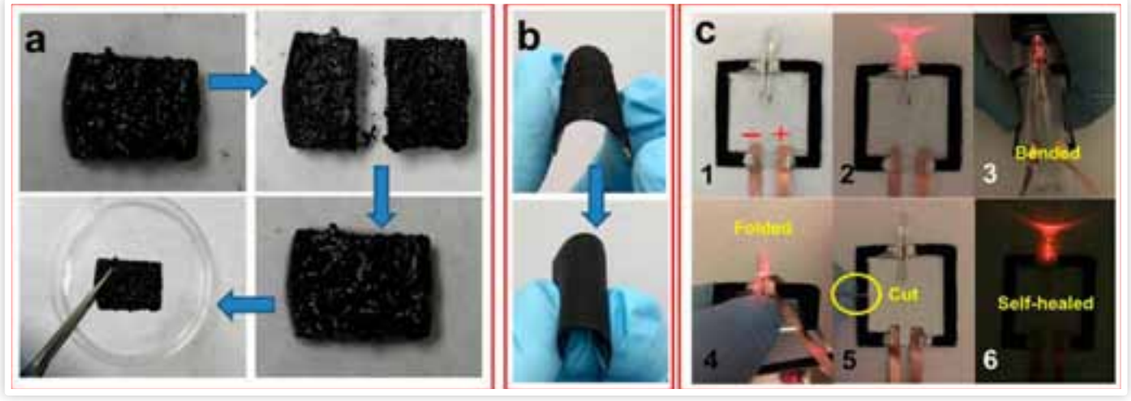
be done with a single camera by setting the sensor to integrate over a longer length of time while sweeping the focal length of the camera and activating the optical stabilization. This will move the image in different focal lengths over the sensor, thus allowing the depth information to be extracted in postprocessing.

Source:https://www.osapublishing.org/optica/abstract.cfm?uri=optica-2-9-822

Electrical circuit made of gel can repair itself

A research team, led by Guihau Yu, an assistant professor at the University of Texas, has created a flexible electric circuit that can repair itself.
The gel's self healing properties arise from a combination of two gels: a supramolecular gel is injected into a conductive polymer hydrogel matrix. This guest-to-host strategy allows the chemical and physical features of the gels to be combined. The supergel provides self healing abilities to the conductive geld due to its supramolecular chemistry, as a supramolecular gel is held together by much weaker forces due to the large molecules. This allows it to easily reattach itself. This allow the hybrid gel to repair itself after being bended, folded and even being cut in mere minutes.

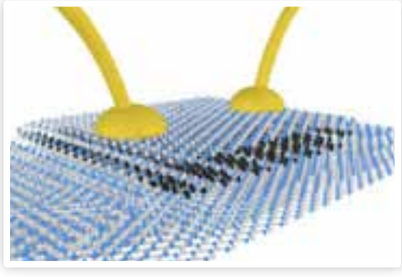
source:http://pubs.acs.org/doi/abs/10.1021/acs.nanolett.5b03069



New, stable 2D materials with revolutionary new properties

Newly designed 2D materials, created by the University of Manchester, are capable of revolutionary new properties. However, the problem has been that the vast majority of these one atom thick layers are unstable in air, so they decompose before their properties can be determined.
This new technique protects these reactive crystals with more stable 2D materials, like graphene, by depositing it in special computer controlled gas chamber environments. This combination of 2D materials in thin layers allows opportunities to control the properties of the materials and create materials "to order" for applications like power electronics and high speed communications.

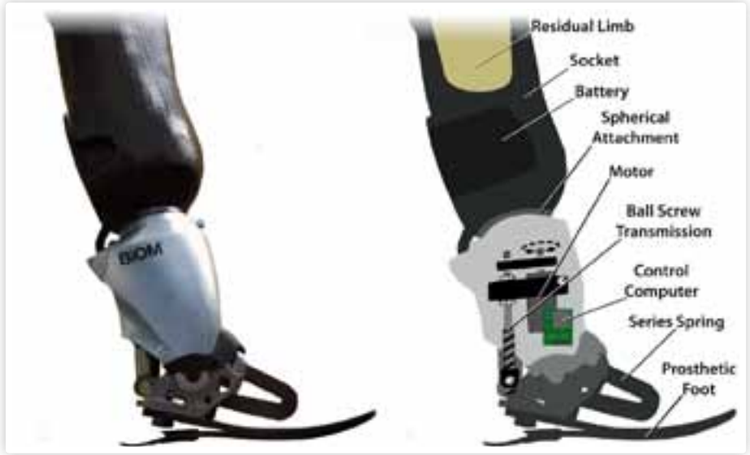
source:http://arxiv.org/abs/1502.03755



Design and testing of a bionic dancing prosthesis

Prosthetic leg research commonly focuses on improving mobility during day to day tasks. Artistic expressions, like dancing, are sadly ignored, leading to severe limitations on prosthetic technology for dancers. The University of Manchester has developed a prosthetic leg which focuses on the ankle kinetics and kinematics during Latin-American dance. The dance prosthesis was designed to provide the appropriate relationship between ankle angle and ankle torque during the steps of the rumba. This was done by biomechanical interaction of the patient through the prosthetic socket. This allowed the prosthetic to significantly outperform a conventional prosthetic.

source: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0135148



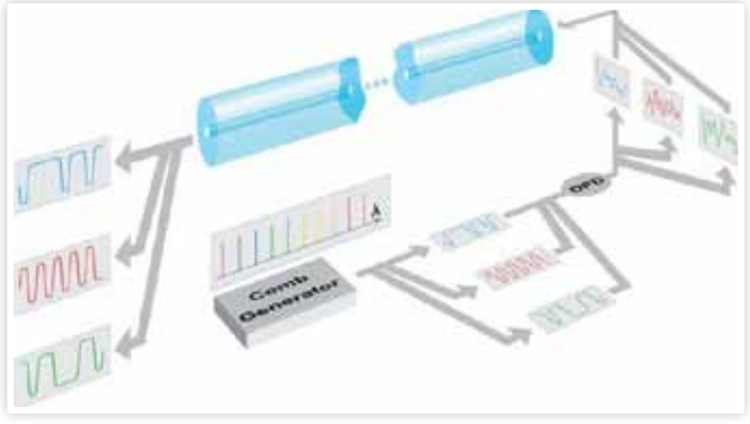
Engineers break power and distance barriers for fiber optic communication

Engineers from the San Diego Photonics Systems Group have broken key barriers that limit the distance that information can travel though fiber optic cable without the usage of electronic regenerators, which are both costly and delay the signal.

The breakthrough relies on wideband "frequency combs" that the researchers developed. The frequency comb distorts the signal in such a way that the crosstalk becomes predictable. Which means the crosstalk is reversible at the end of the cable. This is possible because the crosstalk is not a stochastic process, but deterministic as it is Kerr induced.

Their system performed so well that they could successfully decipher information after it had travelled 12,000 kilometers through fiber optic cables, using standard amplifiers and no repeaters.

source: http://www.sciencemag.org/content/348/6242/1445.full



ASML Internship

a memorable experience in cutting-edge technology and teamwork.

Author: ASML

Nowadays, you can find 16 GB USB sticks on supermarket shelves for as little as €10. This probably isn't something you think about much, but it actually represents quite a significant milestone. One of the high tech players who is working on these kind of milestones every day, is ASML, a manufacturer of lithography systems for producing computer chips.

ASML supplies equipment to all the world's major chip manufacturers including Samsung, Intel and TSMC. There are dozens of steps along the path to producing a chip. ASML helps manufacturers take just one of these steps, but it's a very crucial step. Lithography involves exposing and chemically etching the wafers used to 'print' a chip's components. The degree of miniaturization achievable is fully dependent on the accuracy of the lithography process.
With ASML's latest generation of machines, it's possible to print lines on chips measuring only about 20 nm in thickness. To put this into perspective... that's like printing the contents of a 500-page novel onto a centimetre-long strand of human hair!
You probably think ASML's machines are incredibly complex. You'd be right. Every day, thousands of engineers and researchers dedicate themselves to refining its machines still further. And we are always looking for interns or graduates that want to join them.

Internships

If you are a technical student, you can apply for an ASML internship – and if we can find the right assignment for you, you'll get a memorable experience in cutting-edge technology and teamwork. As long as you are bright, eager to learn, and can work in a team, we will be pleased to consider placing you in our technologically diverse organization. What's more, your technical skills will be strengthened, enriched and stretched – whatever your specialty is. That's because we build machines that are amongst the most complex systems ever conceived. And machines like these require an extremely wide variety of technologies.

Niels Hooger, Electrical Engineering, did a Board Diagnostics intern project:
"When applying for an internship at ASML I noted my interests and skills and the assignment I received fitted my wishes. During my work, the assignment changed, but I was able to retain focus on the parts that interested me most. My best memory of ASML will be the people I met and all the things they taught me. I have never before been surrounded by so much knowledge and experience as I was at ASML."

As an intern, you are part of this cutting-edge technology and work in a multidisciplinary team. You will also experience an international environment and have the opportunity to learn from many different technical specialists. It can therefore be the starting point for building your own professional network.

We offer a wide range of internships and graduation projects, but you can also work with an ASML engineer and formulate your own unique assignment. One that is built around your area of expertise and interest.

We have found that a little creative thinking and a touch of flexibility goes a long way in making an internship rewarding, relevant and enjoyable – for both sides.

How to apply for an internship

Simply visit www.asml.com/students and check out the current opportunities. If you see one that interests you, upload your CV and motivation letter via the website. If you do not find an assignment that matches your interest, then feel free to send an open application. There is always an opportunity to formulate one based on your background and/or interests. We appreciate initiative and support innovative plans and ideas!

Setting a world record in 3D Face Recognition

author: Luuk Spreeuwers

Biometrics - recognition of persons based on how they look or behave, is the main subject of research at the Chair of Biometric Pattern Recognition (BPR) of the Services, Cyber Security and Safety Group (SCS) of the EEMCS Faculty at the University of Twente. Examples are finger print recognition, iris and face recognition. A relatively new field is 3D face recognition based on the shape of the face rather that its appearance. This article presents a method for 3D face recognition developed at the Chair of Biometric Pattern Recognition (BPR) of the Services, Cyber Security and Safety Group (SCS) of the EEMCS Faculty at the University of Twente and published in 2011 [9]. The paper also shows that noteworthy performance gains can be obtained by optimisation of an existing method, see also [11]. The method is based on registration to an intrinsic coordinate system using the vertical symmetry plane of the head, the tip of the nose and the slope of the nose bridge. For feature extraction and classification multiple regional PCA-LDA-likelihood ratio based classifiers are fused using a fixed FAR voting strategy. We present solutions for correction of motion artifacts in 3D scans, improved registration and improved training of the used PCA-LDA classifier using automatic outlier removal. These result in a notable improvement of the recognition rates. The all vs all verification rate for the FRGC v2 dataset jumps to 99.3% and the identification rate for the all vs first to 99.4%. Both are to our knowledge the best results ever obtained for these benchmarks by a fairly large margin. This article is organised as follows. Section 2 presents the basic method (called FaceUT3D). In Section 3 motion correction and in Section 4 improved registration are described. Section 5 addresses classifier optimisation, improved training and outlier removal. Section 6 contains experiments and results. Finally, section 7 gives conclusions.

2 Basic FaceUT3D face recognition method

The FaceUT3D method consists of the following steps:

- Registration - in order to compare 3D facial surfaces, these have to be aligned. This process is called registration.
- Classifier - two aligned 3D facial surfaces are compared using a classifier that outputs a similarity score
- Fusion of multiple region classifiers - the FaceUT3D recognition system uses many classifiers trained for specific areas of the face.

In the following subsections, the different steps are explained.

2.1 3D face registration method

Our registration method does not map one point cloud to another as e.g. in Iterative Closest Point (ICP) based methods, but transforms each point cloud to an intrinsic coordinate system. We use the vertical symmetry plane of the face, tip of the nose and

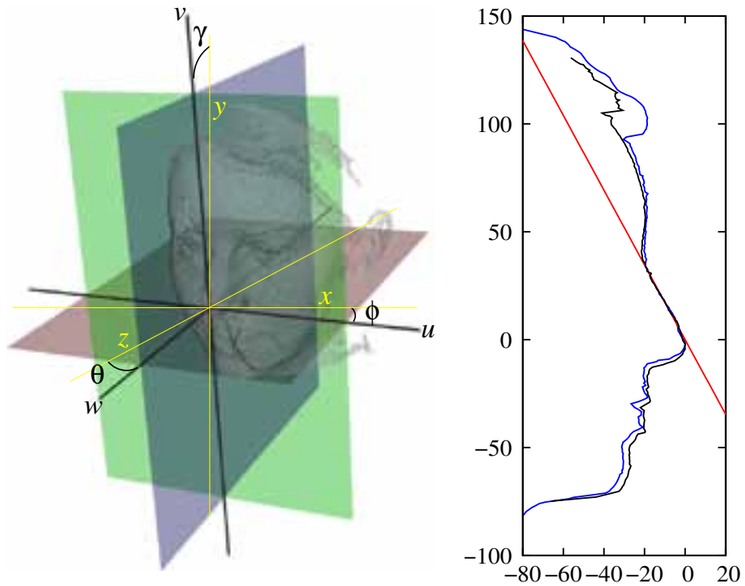


Figure 1: Left: the intrinsic coordinate system with **u**, **v** and **w**-axis of the 3D face is defined by its origin in the tip of the nose and 3 rotation angles: θ, ϕ and γ; Right: definition of tilt using the nose bridge.

the slope of the bridge of the nose to define the intrinsic coordinate system. These geometrical structures are stable under variation of facial expressions. To define an intrinsic coordinate system, three angles and an origin must be determined, see Figure 1. The symmetry plane defines two angles: θ,ϕ. The nose tip defines the origin and the angle of the nose bridge defines the third angle: γ. The intrinsic coordinate system is spanned by the vectors **u**, **v** and **w**. The v-axis is chosen such that the angle with the nose bridge is $\pi/6$ rad. This will generally place faces in a frontal position.

The symmetry plane is found by generating projections of the point cloud to range images of which the image plane is perpendicular to a hypothesised symmetry plane and subtracting the mirrored range images. The smallest difference corresponds to the most likely symmetry plane. A list of possible symmetry plane candidates is kept and a simple nose template is used to select the best candidate, as the nose should be divided in two by the symmetry plane. The symmetry plane is first estimated from a subsampled point cloud to improve speed and subsequently improved using the full point cloud. In order to detect the nose tip and the slope of the nose bridge a profile of the face is extracted by projecting all points of the point cloud near the symmetry plane on the symmetry plane. A rough position of the nose was already available from the symmetry plane estimation. The nose bridge is found by fitting a straight line to the profile in the nose area. The tip of the nose is the intersection of this line and a vertical line through the point with largest x-coordinate in the profile in the nose area (see Figure 1).

A range image is created by projecting all points in the point cloud to a plane perpendicular to the symmetry plane. Post processing is performed using filtering to fill in holes and remove spikes.

2.2 PCA-LDA-likelihood ratio classifier

For comparison of the 3D range images, we use a classifier based on the likelihood ratio, but specifically designed to perform a one-to-one classification. The likelihood ratio that two facial images **X** and **Y** are of the same subject is defined in formula 1:

$$\mathrm{LR}(\text{same subj}|\mathbf{X},\mathbf{Y}) = \frac{p(\mathbf{X},\mathbf{Y}|\text{same subj})}{p(\mathbf{X},\mathbf{Y}|\text{diff subj})}$$

Where the within subject probability p(**X**;**Y**|same subj) is the conditional probability of two images **X** and **Y** given that they are of the same subject and the between subject probability p(**X**;**Y**|diff subj) is the conditional probability given they are recordings of different subjects. If we assume that the within distribution of all subjects is normal with the same within class covariance $\mathbf{C}_w$, but with different means and the total distribution of all facial images of all subjects is normally distributed with total covariance $\mathbf{C}_t$ and mean μ_t , then a simple expression can be derived for the likelihood ratio. First a transformation is applied to the images that shifts the data, decorrelates and scales the total distribution such that it becomes white and simultaneously decorrelates the within distribution, according to formula 2:

$$\begin{aligned}\mathbf{x} &= \mathbf{T}(\mathbf{X}-\mu_t)\\ \mathbf{y} &= \mathbf{T}(\mathbf{Y}-\mu_t)\end{aligned}$$

Obtaining the transformation **T** involves Principle Component Analysis (PCA) using Singular Value Decomposition (SVD) of the total distribution. Also a dimensionality reduction is applied and only the *p* largest singular values are retained. A second SVD is applied to the within class data to decorrelate the within subject data. The *l* smallest singular values are retained that give the best discrimination between subjects. After this transformation, the total distribution of all facial images **x** and **y** of all subjects is normal with mean zero and the identity matrix as covariance matrix and the within subject distribution is normal with diagonal covariance matrix Σ_w. The dimensility of **x** and **y** is *l*.

The resulting expression for the log of the likelihood ratio (LLR) becomes, see [12]: formula 3:

$$\mathrm{LLR}(\text{same subj}|\mathbf{x},\mathbf{y}) \propto -(\mathbf{x}-\mathbf{P}\mathbf{y})^T\mathbf{D}(\mathbf{x}-\mathbf{P}\mathbf{y})+\mathbf{x}^T\mathbf{x},$$

Where $\mathbf{P} = \mathbf{I}-\Sigma_w$ and $\mathbf{D} = (\Sigma_w(2-\Sigma_w))^{-1}$ are diagonal matrices. In expression 3 constant terms are ignored. Expression 3 deviates slightly from the standard expression for LDA based classifiers, where instead of $\mathbf{P}_y$ the class mean is used and $\mathbf{D} = \Sigma_w^{-1}$. Since in a typical biometric case, only few reference samples are available (often only a single one), the class means are not available and expression 3 is the proper expression to use and gives better performance.

To test if two facial images are of the same subject, the log likelihood ratio is compared to a threshold. If it is above the threshold, the two images are regarded as coming from the same subject. The threshold is defined by the required operating point in terms of False Accept Rate (FAR) and False Rejection Rate (FRR) and normally obtained using a test set of facial images. A high threshold results in a low FAR, but a high FRR and vv. The FAR is an estimate for the probability that two images from different subjects are classified as the same, while the FRR estimates the probability that two images of the same subject are classified as different subjects.

2.3 Fusing multiple regions

We defined a set of 30 overlapping regions, see Figure 2, where the white area is included and the black area is excluded. The regions were chosen in such a way that for different types of local variation they would allow stable features for comparison. Examples of such regions are those that leave out the upper or the lower part of the face because of variation in hair, caps etc. or variation in expression of the mouth.

For identification, we use majority voting of the rank 1 classification results of the individual classifiers. The gallery image with the most votes is the rank 1 result of the fused classifier.

We developed a voting fusion approach for the verification scenario as well. First decision thresholds $\mathbf{T}_i$ are determined for all region classifiers using a separate calibration dataset for a fixed FAR that is the same for all region classifiers. To determine the fused score for the comparison of a probe to a reference image, the scores LLR_i for each region classifier *i* are compared to the threshold $\mathbf{T}_i$ of the region classifier and the decisions are accumulated, formule 4:

$$\mathrm{V}(\text{same subj}|\mathbf{x},\mathbf{y}) = \sum_{i}^{\text{all regions}} \begin{cases} 1, & \mathrm{LLR}(\text{same subj}|\mathbf{x},\mathbf{y})_i > T_i \\ 0, & \text{otherwise} \end{cases}$$

The number of votes is the fused score and is compared to a threshold $\mathbf{T}_v$ to reach a decision, formule 5:

$$\mathrm{D}(\text{same subj}|\mathbf{x},\mathbf{y}) = \begin{cases} 1, & \mathrm{V}(\text{same subj}|\mathbf{x},\mathbf{y}) > T_v \\ 0, & \text{otherwise} \end{cases}$$

The threshold $\mathbf{T}_v$ must be determined using a second dataset and again is tuned for a specific FAR or FRR which is not necessarily the same as the one used in obtaining the thresholds $\mathbf{T}_i$ of the individual region classifiers. We call the FAR that is used to obtain the first set of thresholds $\mathbf{T}_i$ the *projected* FAR: pFAR. The optimal setting for pFAR can be different from the FAR required for the fused classifier. We refer to this voting approach as Fixed Far Vote Fusion (FFVF).

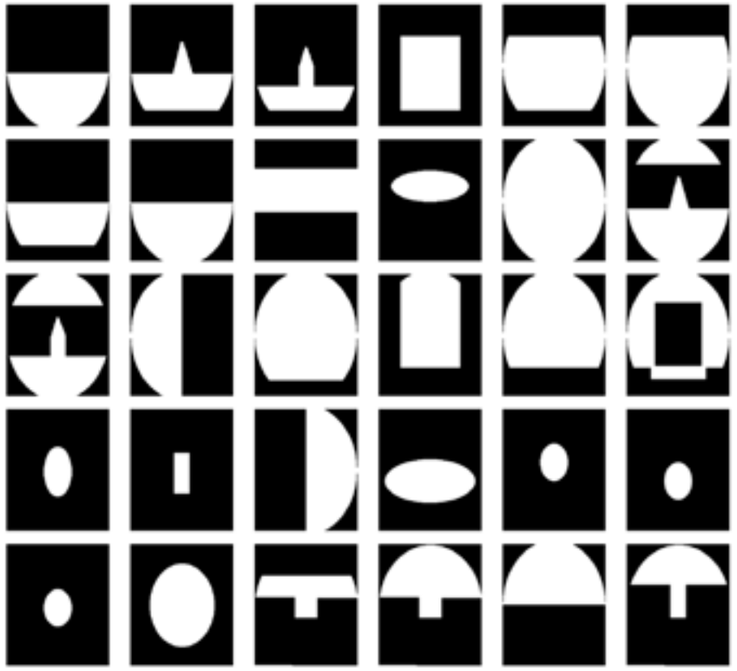


Figure 2: Regions used for different classifiers.

3. Motion correction

One of the most common 3D scanners used for 3D face acquisition is the laser based scanner like the Minolta Vivid 900/910 scanner used to acquire the FRGC v2 data. A disadvantage of these scanners is that they are slow. If a subject moves during acquisition, motion artifacts occur. Examples of motion artifacts are shown in Figure 3.

The motion artifacts are caused by the subjects moving their heads while scanning. Scanning takes several seconds and normally takes place in vertical direction. This means that if the head moves, when the top of the head is scanned the position of the head is in a slightly different position relative to when the bottom of the head is scanned. This results in a plastic deformation and not a rigid transformation (rotations and frontalisation are handled in the registration stage, see section 2.1).

Motions of the head in front of the scanner

Figure 3: FRGC images with motion artifacts

can be movements from left to right, mostly caused by moving the balance from one leg to the other, from back to front and up and down. The latter movement is far less frequent than the first two, because it requires the subject to rise, sit down or jump up and down. A quick investigation showed that by far most of the motions are from left to right. Motion from left to right results in the asymmetric, bent noses in Figure 3. This means the motion results in a deformation of the face which cannot be corrected by registration, which only handles rigid transformations. Normally, it is very hard to estimate motion from a single recording. However, because most faces are nearly symmetric, we came up with a simple approach to correct for the left to right type of motion: if we assume the face is symmetric, every horizontal line of a registered face should also be symmetric. If we force this symmetry around the vertical centre line of the range image, the left-right motion will be compensated for. The motion correction operates on the range image and consists of the following steps:

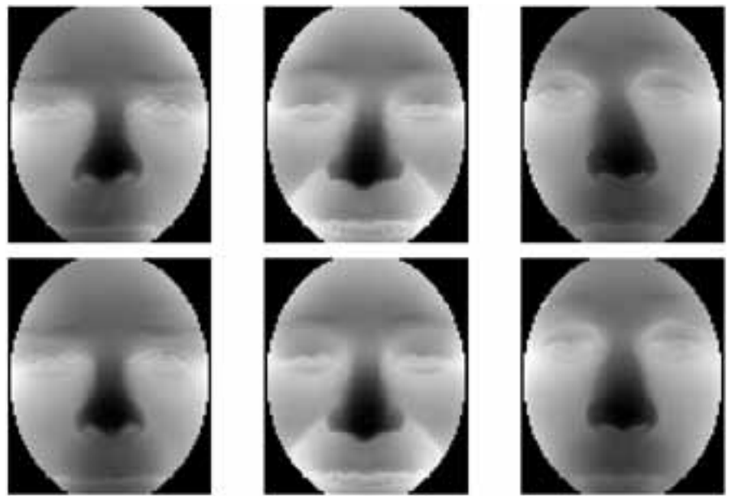


Figure 4: Range images of 3D data from Figure 3 without (top) and with (bottom) motion correction. To see the difference between the original and motion corrected range images, focus on the centre of the top of the nose (between the eyes) and the tip of the nose. In the uncorrected images the latter is not straight below the former, whereas in the corrected images it is. The aximum shift is 5 pixels or 7.5 mm

1. For every line y calculate a symmetry score sy(d) by shifting the line over d and subtracting the depths on the left of the image from those of the right and accumulating the absolute value of the differences.
2. Average symmetry scores over a vertical range yr of a few pixels (or mm).
3. Select shifts with the best symmetry scores.
4. Improve the found horizontal shift to sub pixel accuracy using parabola fitting.
5. Shift each line of the range image with the resulting sub pixel accuracy shifts using linear interpolation.

The resulting range images before and after motion compensation for the examples in Figure 3 are given in Figure 4. Clearly, the motion compensation works well as all the noses are straight in the motion corrected images.

4. Fine registration

In the complete registration process, the estimation of the vertical symmetry plane is very reliable and accurate, because it uses much of the available data. The estimation

Table 1: Rank-1 scores and estimated times for identification of a single probe using a gallery of 466 subjects of the FRGC v2 data.

Method	Total time [sec]	rank-1 score
Queirolo [8]	1864	98.4%
Faltemier [4]	1312	97.2%
Al-Osaimi [2]	50.6	96.5%
Kakadiaris [6]	15.5	97.0%
Alyüz [3]	131	97.5%
Wang [10]	3.2	98.3%
Spreeuwers [9]	2.5	99.0%
Spreeuwers 2014	**0.6**	**99.4%**

of the tip of the nose and the slope of the bridge of the nose on the other hand, relies on far less data, namely the profile of the face around the nose. This might result in a less reliable and less accurate estimate of these parameters. Because the PCALDA-likelihood ratio-based feature extraction and matching processes are extremely fast (up to millions of comparisons per second), it is possible to generate range images for a number of small variations of the registration parameters for a probe image and pick the one that gives the best score. Because the inaccuracies in the registration parameters are mainly caused by the variation in the estimation of the vertical position of the nose tip and the slope of the nose bridge, only 2 parameters need to be varied: v and γ in the intrinsic coordinate system of Figure 1.

5 Classifier optimisation

It is well known that PCA and LDA are sensitive to outliers in the training data. In LDA the class mean must be estimated from a limited number of samples (often less than 10 samples per subject are available).

We propose a new approach to outlier detection based on genuine likelihood ratio scores where the choice of the threshold is determined by the performance of the classifier. The basic idea is to find candidate outliers in the training set, remove those from the training set, then retrain the classifier and check if the updated classifier performs better than the original.

The procedure operates on the individual region classifiers and not on the fused classifier. We assume that initially a PCA-LDA-likelihood ratio classifier has been trained on a training set. Next from the training set, the likelihood scores for all genuine comparisons (i.e. for all variations of 2 images A and B of the same subject) are calculated. We reason that low scores are most likely caused by an outlier. Low scores are scores that are below a certain threshold t. Initially, the threshold t is chosen such that a small set of genuine pairs with low scores is selected (some 1-10 pairs). There are 3 possibilities for a genuine comparison of images A and B: either A or B or both A and B cause the low score and are therefore possibly outliers. To determine which is true, we compare images A and B with the other images of the same subject. If more than half of the comparisons of image A (or B) with other images of the same subject result in low scores as well, A (or B) is considered a candidate outlier. Next the candidate outliers are removed from the training set and the classifier is retrained. If the retrained classifier performs better on a separate evaluation set than the original classifier, the candidate outliers are considered as real outliers and removed permanently from the training set. The whole procedure is repeated but now with a higher threshold t until the performance of the classifierdoes not improve anymore.

6 Experiments and results

To evaluate the performance of biometric recognition systems, generally two metrics are used: identification rate (IR) and verification rate (VR). Identification means finding the identity corresponding with a facial image in a gallery of facial images with known identity. If the list contains N subjects, this means N comparisons have to be performed. The subject in the gallery that gives the highest comparison score is selected. The IR gives the fraction of ima-

Method	verification rate @ FAR=0.1%			
	mask I	mask II	mask III	all vs all
Kakadiaris [6]	97.2	97.1	97.0	
Faltemier [4]			94.8	93.2
Alyüz [3]	85.8	86.0	86.1	
Al-Osaimi [2]	94.6	94.1	94.1	
Queirolo [8]			96.6	96.5
Wang [10]	98.0	98.0	98.0	98.1
Spreeuwers [9]	94.6	94.6	94.6	94.6
Inan [5]			98.3	98.4
Spreeuwers (2014)	**99.3**	**99.3**	**99.3**	**99.3**

Table 2: Comparison of verification rates at FAR=0.1% on FRGC v2 data to top performing 3D face recognition methods

ges for which the highest scoring subject is the correct one. The IR is also called rank-1 score. Verification means a person claims an identity by providing a reference face image (e.g. in a passport) and the identity is verified by comparing a live image with the reference image. If the comparison score is above a certain threshold, then the verification is positive, else it is rejected. The VR is the fraction of correct positive verifications. The VR is often measured at a certain False Accept Rate (FAR). i.e. the fraction of false positive verifications (two images of different subjects result in a comparison score above the threshold). Defining the FAR also fixes the threshold.
For Evaluation of 3D face recognition systems, a benchmark was defined in the so-called Face Recogntion Grand Challenge (FRGC), see [7]. A database is made available consisting of 4007 3D images of 466 subjects with a resolution of 0.6 mm. Standard protocols are defined for evaluation which were followed here. Identification and verification results are presented in the following sections.

6.1 Identification

For the identification experiment, the 4007 images of the FRGC v2 dataset are split into a gallery and a probe set. The gallery set consists of the first image of each subject, resulting in a set of 466 images. Most of these first images are neutral images, but not all of them. The remaining 3541 images are used as a probe set.
Table 1 shows for top-ranking methods the maximum rank-1 performance that was reported. Table 1 also shows the times required for identification of a single probe image to a gallery of 466 subjects from the FRGC v2 data. Identification takes in this case 1 registration/preprocessing of the probe image and 466 comparisons. Our approach gives the highest rank-1 performance and is the fastest method as well.
6.2 Verification

According to the FRGC protocol, the verification rate (VR) at FAR=0.1% is reported for 3 different masks of the data: mask I (within semester recordings), mask II (within year recordings) and mask III (between semester recordings). The results of the verification experiments are shown in Table 2. As can be observed, the optimised version of our method again performs best: 99.3% for the all vs all as well as for mask I-III. The margin to the second best score is in this case also nearly a full 1%.

7 Conclusions

We developed a fully automatic 3D face recognition approach which registers 3D point clouds to an intrinsic coordinate system defined by the vertical symmetry plane through the nose, the slope of the nose and the tip of the nose and determines a similarity score by fusion of many region PCA-LDA-likelihood ratio based classifiers, using voting. We present a number of optimisations to this method: first we describe motion compensation, based on the symmetry of the face. Next we present fine registration by calculating range images for a number of small variations to the registration parameters and selecting the one that gives the highest score. We also introduce an automatic outlier removal approach, which further improves classification performance and trained the region classifiers using more and better quality data.
We present standard benchmark results on the FRGC v2 dataset consisting of 466 subjects and a total of 4007 images. For the all vs all verification test, we obtained 99.3% verification rate at FAR=0.1%, almost a full 1% higher than any earlier published results. For the rank-1 identification performance in the all vs first test, we obtained a recognition rate of 99.4%, again a full 1% higher than the competition.

Acknowledgements

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Assassination week

Author: Bas Keet

Almost everyone has seen one of those James Bond movies or maybe one of the Bourne's. Any other spy movie will work as well. Ever since I have seen one I have always wondered what it would be like to have a secret identity. To live in secrecy and get missions from high placed people to infiltrate some heavily guarded mansion, or fortress for that matter. Using all your way too advanced gadgets to hack into security systems, diving through the bay or other waters all these mansions seem to have, etcetera. And once you're inside get to your target and kill him or her without being noticed. Then get out of the building and stand in front of it to dramatically press the button to blow up the whole thing with the C4 you placed while infiltrating. And last but not least; walking away from the meter high flames while looking insanely cool.

Well the assassination week that was organised was pretty close. Just remove all the drastic exaggeration, replace the gun for a water spewing version and move the location from mansion to the University grounds. Also no actual killing, just ensuring the target got hit by your water gun would be enough. This event lasted from Monday through Thursday. This would allow for enough scheming and plotting to face your worst enemies or best friends.

On Monday everyone was able to pick up their personal head-hunting gear. This meant they were able to obtain a water gun and a target in the Scintilla Room. The rules were then pretty simple; starting midnight when the 8th went over into the 9th of June you are free to "murder" targets. Using your weapon of choice (the choice was an illusion for there were only water guns, but you get my point) you had to shoot the person whose name was written on a small piece of paper you were given with your gun. This target had to be shot in such a way that no one else except him or her would notice it. If someone did notice you, the kill would not count and you still had the same target. This would make it very hard to actually kill your target for he or she then knows who is hunting him killer. Then you could take over the target of the person you shot and continue on your killing streak, for the last person alive with the most kills would win! And the price for the winner was not something to be taken lightly, for it was a fabulous golden Super Soaker! (For those not familiar, it's a large water gun)

According to simple reasoning this would mean you had to get your target to an isolated place for you to easily kill him or her. However since everyone was someone else's target everyone was on edge and suspicious of everything that glanced in their general direction, or even moved. I know I was. So an easy place would be a bathroom of some sorts. However you still needed to follow your target without being suspicious. If I were a girl that would have been easy; "Would you mind joining me to the toilet?" never seemed so harmless. However as a guy my options were limited to spraying myself

the same colour as the walls or just shamelessly barge after my target. No, I needed a different approach, bathroom white does not really suit me.
Other ideas of mine involved waiting at his home (basically stalking), learning his schedule (also stalking), following his route home (more stalking) and other versions of stalking. But I decided that would make me a creep so I just went for the final solution: wait till the perfect opportunity presents itself. A few days passed while I was waiting and before I knew it the 11th of June had already begun. Lucky as I was I had not been shot yet but that luck would stand little chance during the BBQ that night. At the end of this BBQ the winner of the assassination would be presented, this would mean it was everyone's last chance to finish their objectives. I still hadn't finished my first one!

During the BBQ I was mostly safe since I was handing out the meat for everyone. And no one would be so cruel to shoot the person that just handed you food, right? The meat was really enjoyable after all those hard days of scheming, killing and avoiding being killed. There was also a bouncy castle allowing for the much needed relaxation. Shaking off all stress while jumping up and down, the bouncy castle was bounced around as well, but all well that ends well. Then the BBQ became quite lively after someone asked for a swimming pool because it was so hot. Since Scintilla always has the stuff you don't expect it to have, a swimming pool it got. This of course created a splash zone and since all participants of the assassination had water guns with them, this zone easily encircled everybody present at the BBQ or just passing through to the Zilverling. The wet marks left on everyone's clothing were the perfect cover to shoot some targets, because the assassination week was not over yet!

Since my target was also present at the BBQ I just had to make a move. So when at last my target moved from the very crowded outside into the Zilverling I almost intuitively followed. However he of course noticed me following him and looked at me with so much suspicion that I felt like I needed to throw him off. Therefore I stopped following him and headed straight for the toilets. This actually worked since I saw a glimpse of relief on his face before I turned away. So standing in the bathroom it was obvious I needed to change my approach. Thus I spend some time wondering about how I should go about my next move. That was an obvious mistake. An assassin should never stay in the same place for too long. And before I knew it someone came barging into the toilet and emptied his water gun all over me. I had been killed... Oh well, worse things happen.

So effectively I killed exactly zero targets. That would make me a horrible assassin. But at least it was fun being anxious about everything. Plotting all possible moves a target can make and how to adjust your strategy accordingly. Peeking around every corner just to find no one there to shoot you. Wondering if it is okay to install secret camera's in and tap phones since the triple lettered agencies also do it all the time. But maybe I'm just not meant to be a hitman. Or maybe my stealth skills only work while a parade of elephants comes stamping by.

SKIC camp

Summerbbq +
Summercantus

Dogroup market

Microcontroller cursus

Author: Joep Zanen

Building a function generator using a microcontroller

Practically every modern electronic device which features digital (sub)systems makes use of one or more microcontrollers. These chips allow very versatile and complex systems to be implemented easily and at low cost. They are the basis for most systems for human interaction, measurement, control and many, many others. Because of its many uses in electrical engineering, we (Scintilla's Course Committee) consider the knowledge of programming these chips, or at least a basic understanding of its capabilities, an essential skill for every EE student. As the subject of programming microcontroller is only dealt with very briefly, we organized a course to teach the basics of embedded systems engineering using microcontrollers.

Scintilla's microcontroller course

As a goal for the microcontroller course, we wanted our participants to build their very own function generator. A function generator not only is a very handy tool to have, but also is the most hardware based microcontroller project we could think of. To build a signal generator, most of the commonly used hardware peripherals have to be used. Once you can communicate properly with all these peripherals, only a minimal amount of programming "logic" needs to be used to couple everything together to build a function generator. Another interesting aspect of this project is that efficient programming is relevant, as better programming will allow generating higher frequency waveforms, which can be tested in a competition.

To teach this course, we chose to use ARM microcontrollers for their fast processing and universality. This microcontroller architecture is currently the most commonly used for high performance applications. To make the microcontroller into a function generator some external hardware was required. For this, we designed and hand soldered 52 shields with a DAC, a potentiometer, some buttons, some LEDs and the required connectors. STMicroelectronics sponsored their STM32F4-Nucleo development boards and with further material aid from Eurocircuits for the printing of the PCB and Analog Devices for the DACs we were able to teach a course with high quality materials, for a very low price per person.

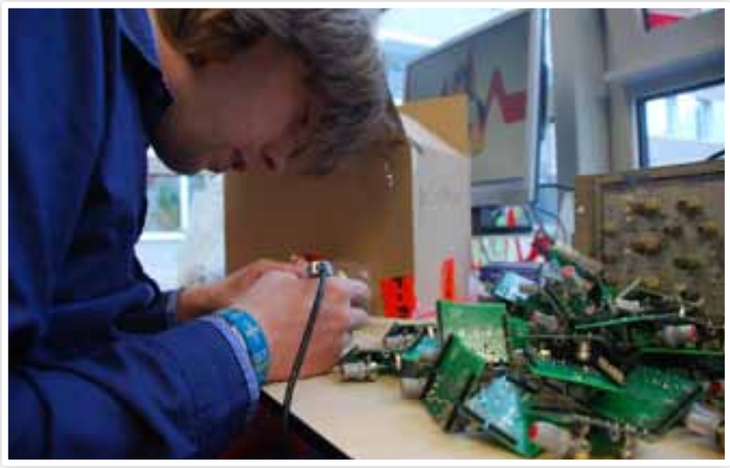


Figure 1 Mickey soldering the custom Nucleo shields

The course would span four evenings and would start with basic microcontroller specific programming in C, the use of bitwise operators and an introduction to the ARM's hardware peripherals, such as the internal counters, analog to digital converter and SPI communication interface. Step by step, the use of these peripherals would build up until the participants were able to read the voltage from a potentiometer, and send this voltage to an external DAC, timed using timer interrupts. With these basics covered, the participants could now start to work on their function generator,, using the beautiful discrete mathematics of Direct Digital Synthesis (DDS).

Direct Digital Synthesis theory

There are many implementations to build a digital function generator, all of which roughly come down to "send out the correct analog value at the correct time". Of course, every approach will have different scores in terms of speed, accuracy in the time and amplitude domain and ease of mathematic programming. DDS is considered to be the most elegant approach, and once you understand the mathematics, it is very easy to program and has the highest performance in terms of speed and accuracy in the time domain. This is why practically all commercial digital signal generators are based on DDS.

Timer interrupts

To send out the correct analog value at the correct time, DDS uses a fixed time base. This time base is generated using timer interrupts. A timer interrupt makes the processor stop its current task and first handle the code which belongs to the interrupt, an interrupt service routine (ISR). It can be compared to setting an alarm for your pizza: first you are sitting and reading a book (or running a program), while in the meantime an alarm clock (or microcontroller timer) counts down until your pizza is finished.

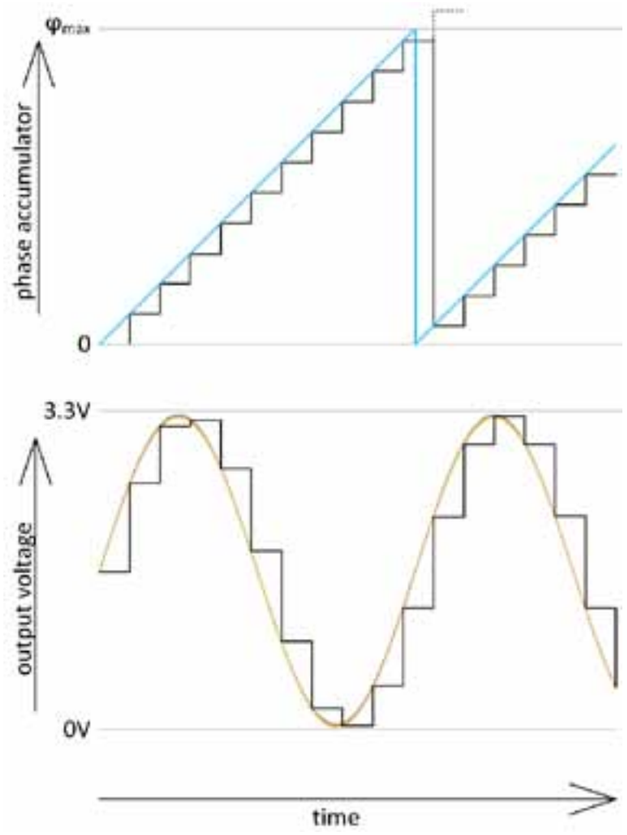


Figure 2 Graphical representation of the DDS phase accumulator and output voltage

Once the alarm rings (or the timer interrupt fires), you immediately put a bookmark in your book and put it aside (or save your variables to the stack) and get your pizza from the oven and eat it (or execute the routine attached to the timer interrupt). Once you have finished your pizza (or finished the interrupt service routine) you return to the page you were in your book (or fetch your saved variables from the stack) and continue reading where you were (or run the program as if nothing ever happened).

In my program, I set a timer interrupt to fire every microsecond. The shorter this period, the higher your sample frequency becomes, but the less time you have to calculate the next value to output. Efficient programming will thus allow you to generate output signals higher in frequency. Considering the used development board has an 84MHz clock, I had a maximum of 84 clock ticks of processor time to calculate the next sample and send it to the DAC. With some optimization this proved possible.

The phase accumulator and the magic number

We now have a time base, but we still have no sense of time, let alone phase. As we want to output a periodic signal, we do not really need to know the exact time; the information where we are in the period is the only thing we are interested in. This phase information is stored in the "phase accumulator", φ. This variable runs from 0 to the highest value efficiently possible in your hardware, in a 32-bits microcontroller like an ARM this number is 2^32-1 or 4294967295.

0 means the phase is at its absolute minimum, 2^31 means we are halfway the period and 4294967295 means we are at the very end of the period. A graphical representation is given in Figure 2.

Every timer interrupt, a constant value, referred to as the "magic number" M is added to the phase accumulator. At sample frequency f_s, the frequency f_pa at which the phase accumulator reaches its maximum value can be calculated as

$$f_{pa} = f_s \cdot \frac{M}{2^{32}}$$

It is important to realize that the sampling frequency is desired as high as possible and to alter the frequency of the generated output, M is set to another value.

Once the maximum of the phase accumulator is reached, an overflow occurs, and the remaining number is added to the next period, which therefore starts with an offset, maintaining the correct phase. This way, frequencies can be generated which are not necessarily an integer fraction of the sampling frequency and the frequency accuracy can be very high.

Generation of output signals

Taking a closer look at the behavior of the phase accumulator, one can see that it generates a saw tooth wave with as amplitude the maximum value of a 32 bit number. The easiest wave form to generate thus should be the saw tooth. As the used DAC has a 10 bit input, the 32 bit amplitude of the phase accumulator has to be mapped to these eight bits. This is in fact very easy, as this mapping is nothing more than selecting the 10 most significant bits. With signals different than a saw tooth, some more mapping has to be used. To translate the information of the phase accumulator to a sine wave, the phase, offset and amplitude all have to be mapped to different values using the following formula:

$$a = (2^{10} - 1)\frac{\sin\left(\frac{2\pi \cdot \phi}{2^{32}}\right) + 1}{2}$$

Doing this in real time uses enormous amounts of processing power, as especially the sine function is a CPU intensive operation. This processing power can be significantly reduced with the aid of look up tables (LUTs). This LUT is a table of pre-calculated values for a certain waveform. Instead of brute force mathematics, the CPU load is now reduced to fetching pre-calculated values from a table. To save memory, the length of this table is reduced to e.g. 12 bits. This means there are 2^12 pre-calculated values in this table, numbered 0 to 2^12-1, which are saved in the array of 4096 entries ""sinewave"[4069]". To find the sine value which belongs to the current phase, map the phase accumulator to 12 bits by selecting the 12 most significant bits and fetch the value witch the corresponding index from the sinewave array.

Implementation in pseudo C

To transform these beautiful and elegant mathematics to an actual implementation, an example in pseudo C is given in Code Snippet 1. The ISR now only consists of an addition, a bit shift, a lookup operation and the writing of the acquired value to the DAC. These are all not very CPU intensive,

```
//the variable for the phase accumulator
volatile uint32_t phase = 0;
//choose a magic number to generate a 5kHz signal
uint32_t M = 5000/1000000*(2^32);
//the array to store the LUT
uint8_t sineLUT[4096];

//the main program
int main(){
    fillLUT();      //calculate the values for the LUT
    initTimer();    //initialize a timer to generate interrupts at 1MHz

    while(1){}      //do nothing and wait for interrupts
}

//the interrupt service routine for the timer interrupt
void TIM2_IRQHandler(void) {
    phase = phase + M;                      //calculate the new phase
    uint32_t int temp1 = (phase >> 20);     //select the 12 MSB of the phase
    uint32_t int temp2 = sineLUT[temp1];    //fetch the value from the LUT
    writeDAC(temp2);                        //output the value to the DAC
}
```

Code Snippet 1 Example implementation of DDS in pseudo C

Figure 3 The Scintilla logo as output signal

which makes DDS a very efficient algorithm. Once you know how to generate a sine wave, you can generate every waveform you can think of. My personal favorite can only be the shape in Figure 3.

Junction

Authors: Lynn Bruins, Mark van Holland

Bert Molenkamp is a teacher at the university. He teaches Programming and Computer Science: On Wednesday the 9th September I was interviewed for the article you are reading now. Approximately 30 minutes the interviewers told me ...more than 90 minutes we talked about different topics, e.g. V-groove etching techniques for integrated injection logic; fail safe control systems for NAM, HTM using Maglog-14 (logic realized with magnetic cores).

Where did you study?

In September 1970 I started the MAVO, and in September 1974 I started the 3 year MTS on EE in Hogeveen. I did not do an internship on the MTS, I got my degree of the MTS after I did my internship at the HTS.In 1977 I Studied 4 years at the HTS Zwolle. I had my internship at Hattem where I worked on control systems.In September 1982 I started at the University of Twente on EE, I studied in the bachelor/master structure which was 3.5 years. My friends said at the time:

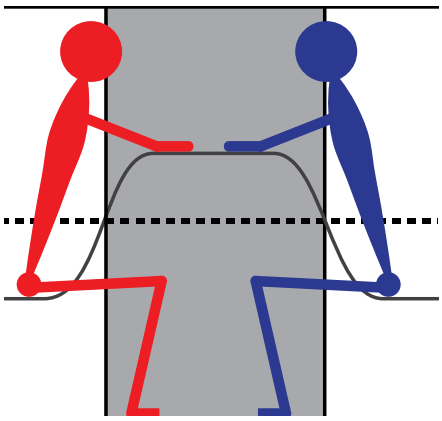
> "Bert is busier getting exemptions then he is studying."

Why did you decide to study EE?

Back in my day, there were not a lot of technical studies, there were only EE, WB, and architecture, and well, I did not like architecture, and WB is with lathes I did not like that. EE seemed fun, also because I already did some hobby projects at home. So subconsciously I already choose for EE before I had to choose a study direction. Other reasons I had was that I was not good in languages, so the study had to be in another subject.

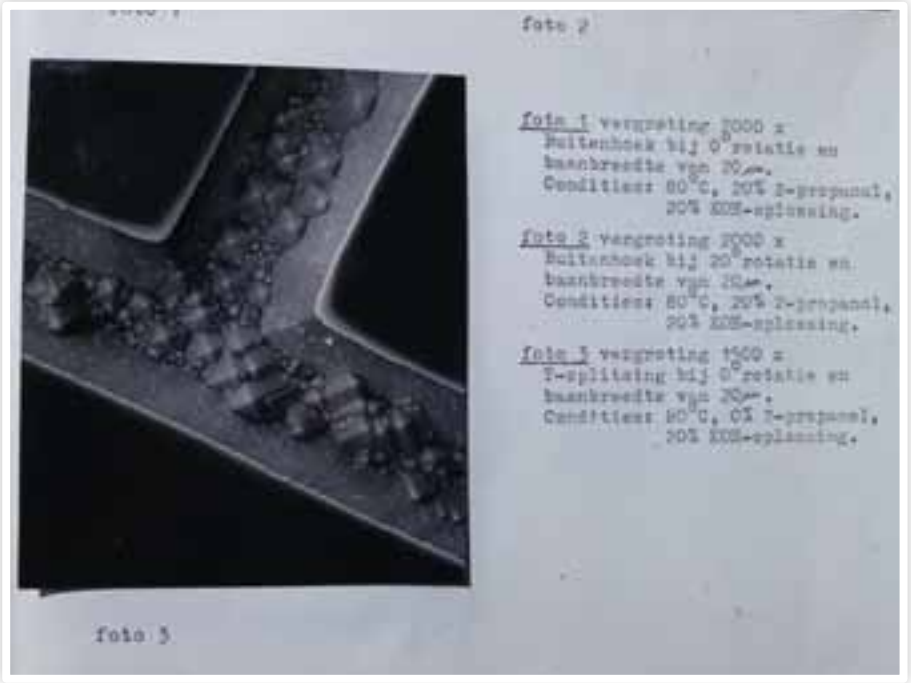
Wat did you do during your internships?

During my internship at WB I programmed control systems, so mostly Controlling Electronics.
In Groningen I made measurement instruments with MatLab. In Delft I worked at the IC atelier where they made IC's, there I made test setups to see if everything worked correctly.



He takes his old reports out of the closet

Everything was written with a type writer which made making mistakes worse, and the pictures had to be glued in.
In Delft we made pictures of the circuit to study it, but the people who developed the pictures told us they all failed,



Egbert Molenkamp

Age	57
Birth place	Appingedam
Favorite Color	Dark blue (jeans blue)
Favorite Drink	Appelstrüdel

so we asked what was wrong and they said all pictures were yellow, but this was because we worked in a yellow room.
My time at the HTS always stayed with me, the internship for it was in 1980, and I graduated one year later. Back then EE was very different from nowadays, because of the time and technology changed, now we do not have dials on the phones anymore.
When I studied at the university, I worked as a student assistant of Leo Veelenturf. I did it for 14 weeks to get an exemption for the internship, but I still had to write a report so it was more of a paid internship in the end.
After I graduated at the HTS and before I started at the UT, I went into service. This was from September 1981 until October 1982. This was because at the time everyone had to go into service for 14 months at the time. I was not allowed to discharge early, because I could not be missed.
My function was driver, the title of my function was B64A9. You did not need a BE driver's license, but you needed to pass the theory exam again. This meant taking the train to Ossendrecht for two months to the driver's course. Afterwards I had to take a two month long radio course in Amersfoort. After those courses I was in the reserves, in 't Harde which lays just south of Zwolle. This meant we had to wait till we would be departed, of course we still had training exercises, and regular inspections. We often had to paint our cars, and then the MIO, Materiaal Inspectie Onderhoud (Material Inspection Maintenance) would inspect the vehicles.
While I was in the reserves I had enough leave time in September 1982 to study every Wednesday, and to make the test. Because I could not make them the other days, the tests were for me always on Wednesday. This would not be possible with TOM.

How did you end up at computer science?

When studying at the university I did my internship at computer science with A. Blaauw. Afterwards I ended up staying at computer science, in the overlapping region with EE, so now I am in the middle of EWI.

How were you as a student?

I was a serious student, and I liked what I was doing.

What subjects do you teach, and in which of the modules?

In the bachelor in module 1 I give programming in C to the first years EE students. In module 5 Computer Architecture and Organisation to second year EE and CS students, and also digital hardware only to the EE students. In module 10 we are setting up an optional module Cyber Physical Systems, here we are going to teach mostly programming hardware like VHDL.
In the masters I teach the subject: Design of Digital Systems, I am master coordinator of Embedded Systems and there are several pre-master students who are doing tasks for me.

What are your thoughts on TOM?

In TOM the students are busier, but so are the teachers. This is because there are more contact hours now than before TOM was introduced. Now the students and teachers are doing about the same amount of work, instead of the students being very busy while the teacher does less. The module coordinators in particular are working harder, because they have to organize several things for students who do subjects double, or students who have to redo a subjects, to prevent that they get double points for the same subject. Students have to work harder and have more test, in the first year they have weekly tests, this all takes time.
The advantages of TOM are that it is often soon clear which students will not make it, and then there is the fact they have to earn 45 points in the first year which shows who can handle the study, and who not.
More ideally, the idea behind TOM was to put everything around one subject, while introducing the system it was changed to fit mathematics in the modules. Math did not really fit in all the modules.

What would be an ideal system? The last system?

The ideal system would also have to be project based, but with grades for every subject, where you would be able to get EC for the individual subjects instead of 15 EC for the whole module or none.This is not all that different of TOM, but still would improve upon it.
Every module math can be a problem for people who do the module for as a minor or for some other reason already had the math of the module, so the best thing would be if every module had extra Math in it for those people.

Did you know early on that you would like teaching Computer Science on the UT?

I started working here April 1st 1986. Then I did also teach within other studies besides computer science. I was asked because there was a spot open. Then I also did some research besides teaching students, but subconsciously I did more and more teaching. Graduates are often involved in the same groups as tutors.

What do you think of teaching at the UT?

I find it fun to do, I chose for it myself, maybe a bit subconsciously because I turned more and more to teaching only, and now I am only teaching. Before I was UD, which was partly doing research, and partly teaching students. Now I am a teacher, and I like doing it a lot.
Besides teaching I still am secretary for CAES (Computer Architecture and Embedded Systems.), so I have to arrange things for the new people in the group, that way the can immediately do their job, so organising workspaces basically.

What did you do before you became a teacher?

Nothing, after graduating I immediately started to work here.

What is your home situation?

I have been married 37 years to Giny. We got married in October of 1988.
My oldest daughter is Alice she is 25 and does not live at home anymore. My other daughter Rianne does her master in Utrecht, she graduated at SPH, and she is 23 and still lives at home.
My son Remco studies Computer Science at the Saxion, he is 21 and would rather be a pilot.

Do you have any hobbies?

My hobby is playing volleyball. During the holidays I also like to read, mostly thrillers. Programming itself also is a hobby, especially VHDL.

Do you have plans for the future?

I do not think I want something very different than what I am doing now, it is important to have fun at work, and I like what I am doing now.

Is there some place you want to visit, or a country you want to see?

We used to go to France with the children, to the beach there. Now we mostly spend the holidays in the Netherlands, just to relax, and be away from it all. We do not have to go on far away trips, we rather go on vacation more often than once far away.

Do you have a life lesson?

> It is more important to do work you like, than becoming rich.

GTT at the Shell Eco Marathon

Author: Ewoud Vissers
Photos: Judith Ritsema

Starting from the first of September last year, the Green Team had worked towards the Shell Eco Marathon for 260 days. The year started with redesigning all aspects of the car, and the biggest undertaking was designing an entirely new shell. The months following this design phase were filled with tons of hard work, and disappointing delays. Still, we had a finished car ready in time for the Shell Eco Marathon, which started for the participants on Monday the 18th of May.

Preparation

The days leading up to the Shell Eco Marathon were killing. Due to delays earlier on in the process, a lot of the car was not finished yet. Many unnecessary features were scrapped near the end, and full focus was set on making sure everything that was necessary during the race itself would work. riskier features could then be implemented after the first attempt was made, when taking more risks was possible.

These days consisted of a lot of coding for the electrical engineers. Thanks to the famous "mickey-coffee" we could work on far into the night, and be ready to go on the next day around 11 again. The first actual test drives were done only 4 days before we'd travel to Rotterdam, on the athletics track on the campus. The first major setback appeared during these tests. After a few laps, the car couldn't bring itself up to speed from a full stop. It turned out the left front axle had bent, and caused too much friction. This meant the mechanical engineers would have to build a new axle, in the weekend. The hardest part was the hardening step in this process, because the tools were in the university, which was closed. In the end, the hardening process was done at the glass blowing workshop of Maurice's mother. The ovens there would go to the necessary temperatures of around 1000 ^{0}C. After this process had been completed successfully, we were ready to go to Rotterdam with renewed courage.

Day one

The night before we left, we had stowed the entire workshop into three trailers, and we started the big move to Rotterdam at 8 o'clock. Sadly, the weather was bad when we had to set up camp, so the week started cold for everyone. The paddock we got was smaller than we had expected, but we've gained a lot of experience with working in small locations this year. This didn't turn out to be a problem (yet). This night a few small electrical issues were fixed, and we could go to bed relatively early.

Inspection: Check!

Day two

Today was the first day of technical inspection. This roughly translates into: Almost all teams waiting in line, while still working on their cars. Sadly, we were doing the exact same thing. The lights had issues when they were connected to the CAN bus in the car itself. The lights would respond only to the first few CAN packets sent, and their microcontroller would crash after this.

This issue couldn't be fixed before it was our turn to enter technical inspection. We started anyway, because the inspection can be done partly as well, and all mechanical aspects were ready for it. The technical inspection consists of a few parts, including the dull but necessary safety inspection.

The test started with easy checks, like whether the car was built inside the size and weight specifications set by the organizers. Our car passed it easily. It was built to the maximum length, (we were short 3mm), and weighed only 82 kilograms, way below the maximum limit of 225. After an easy test of turning radius, the often feared visibility test was next. Many teams have issues with visibility in their vehicle. For us the test was quite easy, thanks to the clear canopy where the driver sits. This ensures the driver can look in all directions.

The visibility test is not the least passed test though. This has to be the brake test, where the car is set on an incline with engaged brakes. The car then has to roll for 30cm's, and stop using its brakes in another 40cm. We cleared this test right on the edge, with a great sigh of relief heard from the mechanical engineers.

Day three

In the electrical inspection, the only problem was the lights not working. We could fix it that night. It turned out the lights were using a somewhat older version of the CAN library which would lock up the microcontroller when certain packets would arrive. This meant we could easily pass the inspection the next day, and because we were almost done, we were allowed to skip the queue as well. After this inspection, we were ready for our first practice runs. Due to the track closing, we were able to run 5 laps, in which everything went smoothly. The only thing we weren't able to test the clutch system. We were all relieved about this run, and thought we'd be ready for the actual race, but nothing was further from the truth. This day turned out to be disaster day number one.

After a small tweak to the hydrogen system it had to be tested. In order for this to work, the entire powertrain has to be started, including the car's boost converter and capacitor bank. During this test, the boost converter started to smoke. The MOSFET in the primary converter had failed. It had taken a bit of the PCB with it, but nothing that couldn't be fixed with some good soldering. This fix wouldn't last long though. After resoldering the primary boost converter, the system started again. The capacitor bank is charged to 48 volts, with a supply around 30 volts. The first 30 volts would be charged without the boost converter doing anything. When the boost converter started boosting, all hell broke loose. It shorted the capacitor bank over two mosfets. These of course instantly caught fire, as anything would do when 17 farads at 30 volts is shorted over it. It was the first time anyone in the team had seen a complete hole burnt into a PCB. This turned out to be major setback number two.

Day four

This day was all about fixing the boost converter. All electrical engineers were up early, and different solutions were being worked on in parallel. The connectors that were

The boost converter causing most trouble this year.

used in previous year's boost were exchanged for LEMO connectors in this year's car. This meant converter cables had to be built to use these components. All components for this year's boost converter were bought at Farnell, and the backup PCB was dug up. Also, a team went around all teams on the ecomarathon, who could maybe help us with a spare boost converter. The following day we'd decide which solution to use.

Day five

Today was a special day for Green Team and its partners, because we had invited all of the partners to come to the race, and take a look around. We had of course hoped our car would work better during this time, but in the end we heard from all partners they enjoyed watching us work with such devotion on fixing the car. It was also the day of the official Eco Marathon opening. Shell spared no expense, and made a real party of it, with dancers, music and everything. I haven't really seen much of it, since I was working on the car. We had decided to use the boost converter and capstack of last year's car. The electrical engineers were devoted to testing all the new (old) systems, and fixing small bugs with them. We also tried to reprogram the old components, so they could communicate with the modules in our new CAN system. This would mean we could monitor the capstack during the race, and detect possible problems.

Day six

Today was the day for the first official attempts in our category. We had a small part of the team get up before 6 AM to reserve a spot in the line. The race would start at 9. Also, the fuel cell still had to be reinstalled, so this was the time to do it. Everything seemed to go well, except for the fact that the Fuel Cell voltage wouldn't rise to high levels. This meant it couldn't create enough power to drive the vehicle. This might have been a sign from God, because if it worked, we would have had to drive through rain. This would have been very risky, since the motor controllers are very close to the wheel arches, and water could be splashed onto them. We were still heavily stressed though, and started troubleshooting. The problem was found quite quickly, the air pumps were blocked, so the fuel cell was missing a crucial ingredient for the chemical reaction necessary to create power. This problem was fixed, and the rain had stopped as well. It seemed like everything would go smoothly from now on, and we went into the fueling tent. Time was ticking, and there was a timeslot of 10 minutes to get onto the track before it closed. We had to be checked on a few points before we were let on to the track, to make sure we were not cheating. One of those checks is the briefing check. The driver of the vehicle has to attend a briefing every morning, and isn't allowed on track otherwise. The driver badge would be scanned there, so it could be checked in the fueling tent. Something had gone wrong with the badge of our driver, so the organizers had to check using old school questions. This took longer than planned, but we were let onto the start line in the end, with only a few seconds left on the clock. Then the organizer closed the track, and we had to wait until the next attempt, in the evening that same day.

The H2Zero during attempt #2

Because we couldn't start our attempt due to Shell's fault, we were allowed to go first in the next run, and skip the entire line. This gave us a big relief because this meant we could do more checks on the car before we had to drive. Maybe this wasn't for the best. The afternoon before the attempt we still did a few small laps on the test circuit, right in front of our paddock. This was on a normal parking lot, and all potholes had been covered with pylons. Except for one, which could not be seen from the low driver height. This meant we drove straight into it. It gave a horrible sound, and it turned out our right front suspension had cracked. The shock from the pothole had torn apart the sandwich-panel that fixed the suspension to the body. This had to be repaired in 2.5 hours, before the new attempts would start. This was the first mechanical problem encountered during the SEM itself. This was a bit of a relief for the electrical engineers, who had all systems working perfectly.

The dreaded cones at our first attempted start

The suspension was fixed in time with the help of many people. The people of HAN Hydromotive had seen us driving into the pothole, and immediately came to help out. The only fix that could be thought of in time was to reinforce the sandwich-panel with plywood. The plywood was cut, and a large team set out on a quest for the proper glue. The best one came from HAN, which would dry in 1.5 hours. The panel was quickly applied, and there was a full-time job of speeding up the drying process, with heatguns. It was fixed in time, and we were very happy to start our first real attempt. Everything seemed to go quite well, except for the fact that the car wouldn't speed up past 26,5km/h. This meant our average speed was too low to complete the race in the specified time limit.

After this race, the team started troubleshooting again. The power required was way higher than during the first practice run. We had driven on an average of 240W, while the practice run was around 140W. There was a serious issue, but it couldn't be found immediately. The first things we did were increasing the current limit in the motors, providing more torque, but running them severely out of spec. We had backups anyway. This meant the fuel cell had to work harder as well, which was accounted for with a few software changes as well. At the end of the night the issue was found. The transmission required 40W to start turning, without any load at all. The gears were not at the right distance anymore. This was fixed by tying the backs of their axles together with a lot of tension, pulling the gears away from each other.

Day seven

The final day started extremely well, without any problems. We could enter the track immediately, and the driving went a lot better. We reached a speed of 31km/h, and our track times were exactly on the limit every lap. It seemed like this attempt we'd finally make it. Until, halfway in lap 7, the car stopped. The emergency stop had been triggered. The only way this can happen without someone pushing one of the buttons is if there is more than 1 percent hydrogen in the electronics compartment. The hydrogen sensor in the car will than trigger the emergency stop. It was really odd, because the system had been checked for leaks just before the race. We didn't have time to think about this though. The track would close in 10 minutes, so we pushed the car the fueling tent as fast as we could and we reached the tent in time to start another race. This one lasted only 3 laps, and the same problem occurred. This meant we have no valid result again this year. It turns out the emergency stops were due to the heat. The final day was a beautiful summer day, with temperatures of 25 degrees, and lots of sunshine. The transparent canopy therefore gets extremely hot. The sensor would drift, and set off the emergency stop without exceeding the hydrogen limit. This will definitely be the first system we'll change next year. And we'll immediately test it for extremely poor weather as well, because the next Eco Marathon will be held in London. I wish the new team lots of luck in their year, and genuinely hope their SEM experience will contain less problems.

Eventhough we had lots of issues with our car, we still went home with a prize this year. We have won this year's communication award, which is rewarded to the team with the best public relations. We had lot's of people of the team working hard on that this year, so we were very happy with this prize.

Team photo after winning the communications award

on location

First year company outing

Author: Jippe Rossen

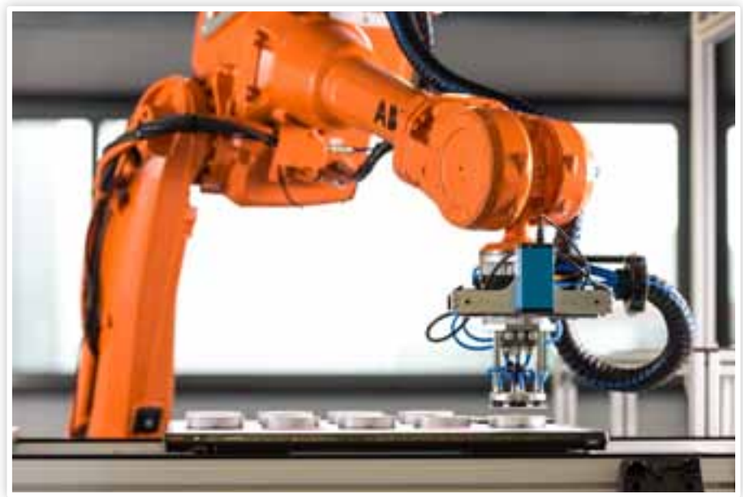
It is 8am on a rainy Tuesday morning when I open the Scintilla room to make some final preparations for this exciting day. On June 2nd the annual first-years-company-excursion was planned. During this event we organize a company visit for all first year students. The transition from high school to university is often a troublesome one, the workload increases drastically and tasks which usually took no effort at all, suddenly require loads of work and are much more difficult as well. In addition the material is mostly theoretical and it is often unclear why you would need all this knowledge.

The company visit shows the students what they can achieve later on if they pass the program and become credited engineers. It also shows the material treated in classes on the most applied way there is. The program board thinks this day is of such importance that they schedule a day off every year so Scintilla can organize this event every year.

This year, however, is a bit more special than the past editions of this activity. We usually stay close to the university for organizational reasons. Today the total group of students was split up. One of the groups would go all the way to Eindhoven by touring car. In Eindhoven we would visit AME (Applied Micro Electronics "AME" BV), a company that specializes in developing and manufacturing complete high quality electronic products. Whilst the other group stayed behind in Twente to experience all the cool and secret works of THALES.

Equipped with one of the Scintilla flags I arrive at the parking lot where I told everyone to meet up at 8:45. Some early birds were there already at 8:40 which was a pleasant surprise for me. Around 9:05 we left the University of Twente with a bus filled with 34 electrical engineers (and luckily 1 bus driver). Some persons were prepared and soon began playing card games in the bus. Others took the lecture free bus ride as an opportunity to pick up some postponed studying, or to get some additional sleep.

After a bus ride of about 2 hours we arrived at AME. Here we met Gijs van Miert through whom all the communications went between Scintilla and AME. The day began with coffee tea and some biscuits to get started. After that we were given a presentation about the company. He explained that AME does not only wants to design high quality products but really creates them in Eindhoven. He explained that when the complete product is developed in-house, the general level of affliction with their products increased as well. In-house production and complete product responsibility brings some additional challenges. Design of the products, including electronics (hardware and software) and mechanics, is not the final step at AME. Industrialization is next. This means their engineers have to go the extra mile to cleverly think about assembly, test and material and component selection. Decisions mostly seem simple but the practice at AME shows to be more difficult. For example, using a single component 5 times instead of using 5 components only once.
When you really create the product yourself, it makes it possible to identify such simple but important issues. When the design is fabricated by a third party they are unlikely to point out that your design could be better.



During the presentation we were also shown some neat built in gadgets of their building. They implemented a self-made light controlling system for the entire building attached to a web interface on their intranet. By going to that webpage you could monitor and control the lights in all the rooms in the building. Which he demonstrated by turning off the lights with his computer. I personally doubt it brings them an advantage over their competitors, but it was fun to see their passion for technology.

After the presentation the group was split in half, one group would start with a tour around the facilities and one group would work on a case. In the case the students had to do some calculations on a measuring system that was used to drive a motor controller. It was a nice practical example of how to implement the theory of your education in the field of professionals.

The tour was about 90 minutes long and took us through all the facilities AME has to offer (e.g. laboratories, EMC room, electronic and mechanical production). Since AME does all its activities in-house except for the actual etching of their PCB's, this is quite a lot. During the time of our visit they were just about done with upgrading most of their machinery. AME possesses two fully automated production lines! This starts with machinery to deposit solder paste, after which every component is automatically picked and placed. The complete PCB assembly is fed into a reflow oven after which it will be tested fully and automatically. In another building there were some more robots that were used to fabricate mostly mechanical parts for the casings and other mechanical parts of their products. Assembly of all components (e.g. PCB assembly, mechanics and other materials) are assembled mostly automatically, which includes a fully automated gluing robot.

Some nice feature that is still worth mentioning is their logistic monitoring of every product in their facility. Every part is labelled and added to their database as soon as it enters their facility. That way every part can be individually tracked and traced.

After the tour there was of course some room for drinks and some snacks. During these drinks people were still discussing the things they have learned and seen this day. All in all this was a great excursion with loads of cool toys for an electrical engineer and if you have ever the opportunity to visit AME, you will not be disappointed!

Scrapheap Challenge

Author: Daan Pendavingh

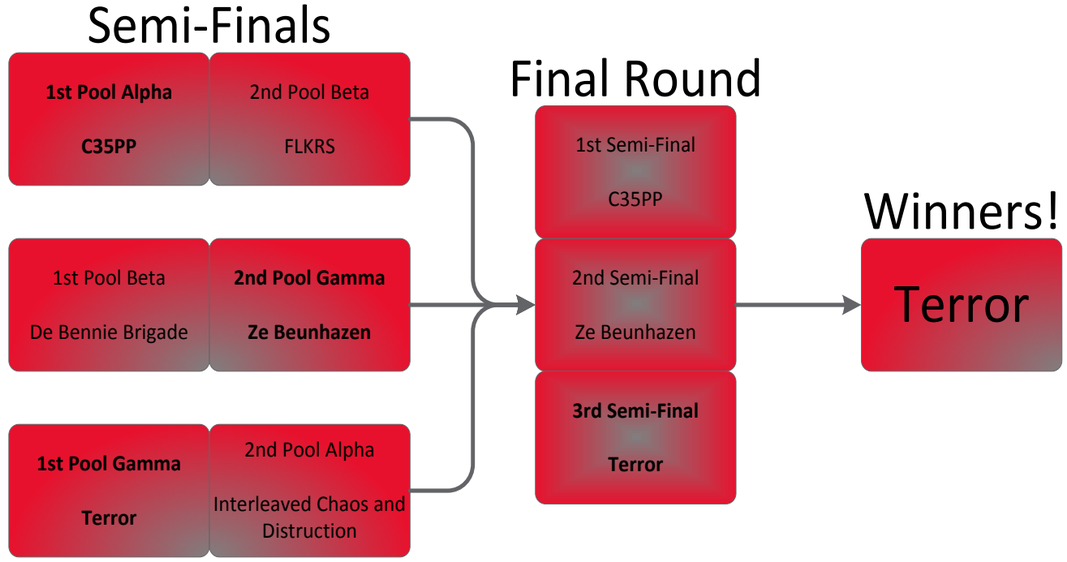
The Scrapheap Challenge: Electrical Engineering is one of the most fun and exciting events of the year. The Scrapheap Challenge is all about teamwork en creativity. The idea of the original Scrapheap Challenge is that a number of teams have one weekend on a Scrapyard to build a machine. At the end of the weekend the teams do the challenge, the winner gets infinite amount of fame. What kind of machine they have to build is announced only minutes before the start. The teams have to act fast to get the most valuable scrap. Probably you can guess now what the Electrical Engineering edition is all about. The teams all share one big pile of old electronics, with this and some tools they have to build their machine in only 24 hours.

On Friday evening all the teams came to the challenge announcement drink where we of course told them what the rules where and more importantly what the challenge was. This year's challenge was to build a boat that had to navigate to a beacon. It transmitted an infrared and ultrasonic signal. When the beacon started transmitting the boats had to start racing for the finish line as fast as possible. The fastest team advanced to the next round. To help the teams a bit each team was supplied with one Infrared photo-transistor and one ultrasonic piëzo receiver.

> "After a long first day most of the teams had already something that started to look like a boat."

The next day all the teams came early some dressed in their team outfits others with their mascot. When all the teams found a nice workspace, perfected their looks and some final announcements where made the scrapheap was opened! The search for the most powerful motors had begun.

> The search for the most powerful motors had begun.



After a long first day most of the teams had already something that started to look like a boat. The teams had to stop constructing at 21.30 and then they could brag about their creations at the drink afterwards, but first all teams had to return all the scrap on which they were not working back to the scrap yard. The next day the teams started with a fresh look and continued working on their boat.

> "It turned out that the detection of the beacon was quite hard, some were able to detect the signal but when the signal was lost the boat turned off."

It turned out that the detection of the beacon was quite hard, some were able to detect the signal but when the signal was lost the boat turned off. A group of freshmen used a microphone for the autonomous start; the plan was that it could trigger their boat with a clap or other noise. But after some testing it turned out that a few seconds after the clap their boat turned off. The solution was that one person constantly needed to scream really hard to keep the boat on. Another group built a wired remote that was also able to have control of their steering rudder.

The second day went really fast, after diner every team took their boat outside for the challenge. The challenge started in 3 pools of 4 or 5 teams. Teams C35PP, Ze Beunhazen and Terror won the semi finals and fought a super intense battle. And the winner is ..... Terror! Their self-made centrifugal pump was the key in winning the super awesome trophy. But there is more, ACME won the originality price with their rowing boat. Everyone had a great weekend and we hoop to see you all next time, The Scrapheap committee

solarteam

SolarTeam

Author: Fieke Hillerström
Photos: Jérôme Wassenaar

When I was a child, I built a small wooden pickup together with my father. The pickup is still on top of the closet at my parents' house. Large wheels and at the front a grill from matchsticks, from which we even had burnt the head, to make it look more realistic. I was really proud when we had finished the car and I could play with it. Impatient, as a child, I didn't like the time my father spent thinking about the construction. I wanted to start sawing, gluing and nailing immediately. Why did we need to think, while building was a doing business? While working at the solar car project, I get more esteem for the working-patience of my father. Now I understand why my dad tried to learn me one of the basics of construction; think before you start.

Simplicity is the keyword

When I first saw The RED Engine from the inside, I was surprised by the simplicity of it. A few wires and electronic boxes: that was the whole electrical system. 6 LEDs to use as flashing light and a small LCD-screen for the rear-view camera. Only what's needed, is present. Every part, bracket or hole, has its usage and is thought of thoroughly. Of course, this sounds logical, but I didn't really realise what simplicity meant, until I saw it. This simplicity makes that you not only have to think about the electrical design, but also about the housing, weight and placement inside the car. This year I was part of the team that faced the challenge to design and construct a solar car, as simplistic, as needed.

Optimizing solar energy

The solar panel is one of the parts that show how important the design process is and how every electric design is related to the other disciplines. You start with the electrical design of the solar panel. All the solar cells are divided under several Maximum Power Point Trackers (MPPTs), like Elmar once explained in one of the vlogs of Solar Team Twente. These MPPTs are used to make the most energy out of the solar cells and boosts or bucks the voltage of the string of solar cells, towards the battery voltage. MPPTs use smart algorithms to adapt the converters to the changes in incoming solar power, due to shadows for example.

To obtain the best electrical performances, a trade-off has to be made between the amount of MPPTs and battery voltage. Using more MPPTs means more possibilities to compensate for solar cells with lower radiation, but is also means a higher conversion factor, which means more losses. With every design problem and trade-off you have to make choices and I have one advise: Better make a choice than let time choose for you. In the end, a good implementation of your decision can have more impact than the decision itself.

The power from a string of solar cells, is limited by the solar cell with the lowest incoming radiation, because the solar cells are placed in series. To bypass the solar cells with the lowest radiation, diodes are used. This is especially useful in cases of shadows caused by the canopy, or clouds. But the more bypass diodes, the higher the losses and the more time I have to spend soldering. Although, the amount of work does not seem to influence decisions at Solar Team Twente.

Puzzling with cells

After the crucial decisions about the amount of MPPTs and bypass diodes are made, the solar cells have to be fitted on the top of the car. Solar cells are very fragile from itself, therefore laminates are used to protect the solar cells from damaging and cracking. The sizing limitations of the lamination process makes the designs an interesting puzzle. After we, electrical engineers, decided where we want to place the solar cells, we have to look at the structural design of our body. A smaller car has a lower frontal area and can be constructed lighter. To make the car as aerodynamic as possible, a perfect fitting deepening is made to fit in the laminated solar cells. This has to be processed into the design of the plugs, which are used to make the body. Like the solar panel, all these parts that look simple and standard from the outside, brings a lot of design challenges for the whole constructing team.

Crazy weeks, working late... All worth it!

More than one year ago, I paused my studies and started an amazing experience. After a year of hard work, our car is finally on his transport to Australia and I will follow in September. It is time to see how all these small choices became one perfect simplistic solar car and time to face our challenge. I am looking forward to the start of the Bridgestone World Solar Challenge, the 18th of October. Starting from designing and a lot of discussions, we went to the production and realization of our dream. The last two months were about testing the solar car and finishing all the spare parts. It were crazy weeks, but I will remember them as one of the greatest period of the project, for sure. Working late, finishing all the remaining parts in time, but also working with passion and learning a lot about everything. I think we had a record of package delivery in the week before the transport box left. A year of hard work, crazy thoughts and unique experiences; Totally worth it!

Yeah, it sounds crazy: A few years ago I could not drive a car, this time I am building a real one.

Curious about the team and Red One? Follow Solar Team Twente at Facebook and their website www.solarteam.nl!

Inside, outside or within society?

Author: Dieuwertje ten Berg

University is a place where people can develop themselves, to discover who they are and what they want in life. My years as a student have allowed me to view the world in different ways. University is meant to educate and develop people, so that they can make a difference in the world, so that they can contribute to society. But I have yet to experience an environment where you are so striped from society while being a part of the society. The world of the university is a society within a society.

Especially at the UT, and I live on campus so that probably makes it worse, is it so easy to forget the rest of the world. All the persons on the campus have one thing in common, the fact that they study here, which (in most cases) means that they have a decent amount of brains in their head and know how to use it. There are some cases that make the exception to this rule, but let's forget about them for the moment. We are all creative, curious, intelligent people. And sometimes it can be really easy to forget that the population of the UT is not comparable with the general public. The world is bigger and more diverse. It can sometimes be easy to forget that there are people who are less intelligent or don't work and think the way we do. Yes, I know that I'm generalising now, but if you think the differences within the UT are big, imagine how you would experience the differences outside of the UT.

But also with smaller things, for example, something as simple as gas prices. When I was in high school I knew those prices, I knew what was considered cheap and expensive. Nowadays, I have no clue. I don't have a car; a car has not been a commonly used transportation device for the past five years for me. It's not a part of my world anymore. And that while it is the most commonly used transportation method for allot of people.

> I often forget that there are less intelligent people in the world.

Perhaps all our worlds differ like this. That everybody has something that is different from 'normal'. But still I find this very contradicting. I live and study in a place where I'm being educated and are developing myself to become a well-developed, useful citizen. (This might sound stupid, but this is the purpose of education for the government) And at that place I also really distance myself from society. I often forget that there are less intelligent people in the world. Things that are very common are not common to me anymore and things that I find normal are not so normal. But despite all that I still will become a good citizen (hopefully). Mindboggling, if you ask me.

Perhaps this might be the very essence of diversity. The fact that life itself will make you different from other people. That diversity is in the very essence of life itself. And that these differences, or the realization that the world is bigger than your own world, can make you a good person. That would mean that being a little bit isolated from society would make us able to look at it from a different angle. The angle that we might need in order to make a difference in the world. Or perhaps my brain just makes me think like this, because people have a psychological need to be useful. But for the sake of simplicity I'm going to ignore that psychological mechanism.

Have you ever experienced this? Or did you have a completely different viewpoint? Let me know, I'm curious to hear!

Dieuwertje

Puuzle

Author: Truusje

This edition, Truusje has prepared a few tricky riddles for you. Please send your answers to every riddle to truusje@scintilla.utwente.nl.

Truusje finds herself stranded on a mystical island with a drake. After a few days on the island, there appears to be no food and Truusje and the drake are both getting quite hungry. Realizing the only chance of survival is eating each other and knowing she has no chance surviving from the drake, Truusje proposes a challenge.

On the island are exactly ten magical ponds. No less, no more. Each of those ponds produces a completely clear liquid. Those liquids have magical qualities. If you drink out of any of the ponds you will die after 5 minutes. However, if you drink a liquid from any higher tier pond before the 5 minutes have passed, the effect will be completely negated. These tiers are determined by a number. Pond 1 to 9 are on the ground, while pond 10 is up on a steep mountain side, to which only the drake has access. Truusje and the drake have to get a vial filled with one of the available liquids and give it to the other to drink. Both drink the entire contents of each other's vial and are then allowed to drink from only one of the wells on the island.

In the end, Truusje survives and the drake dies. They both drank everything in the vial, so how did this happen?

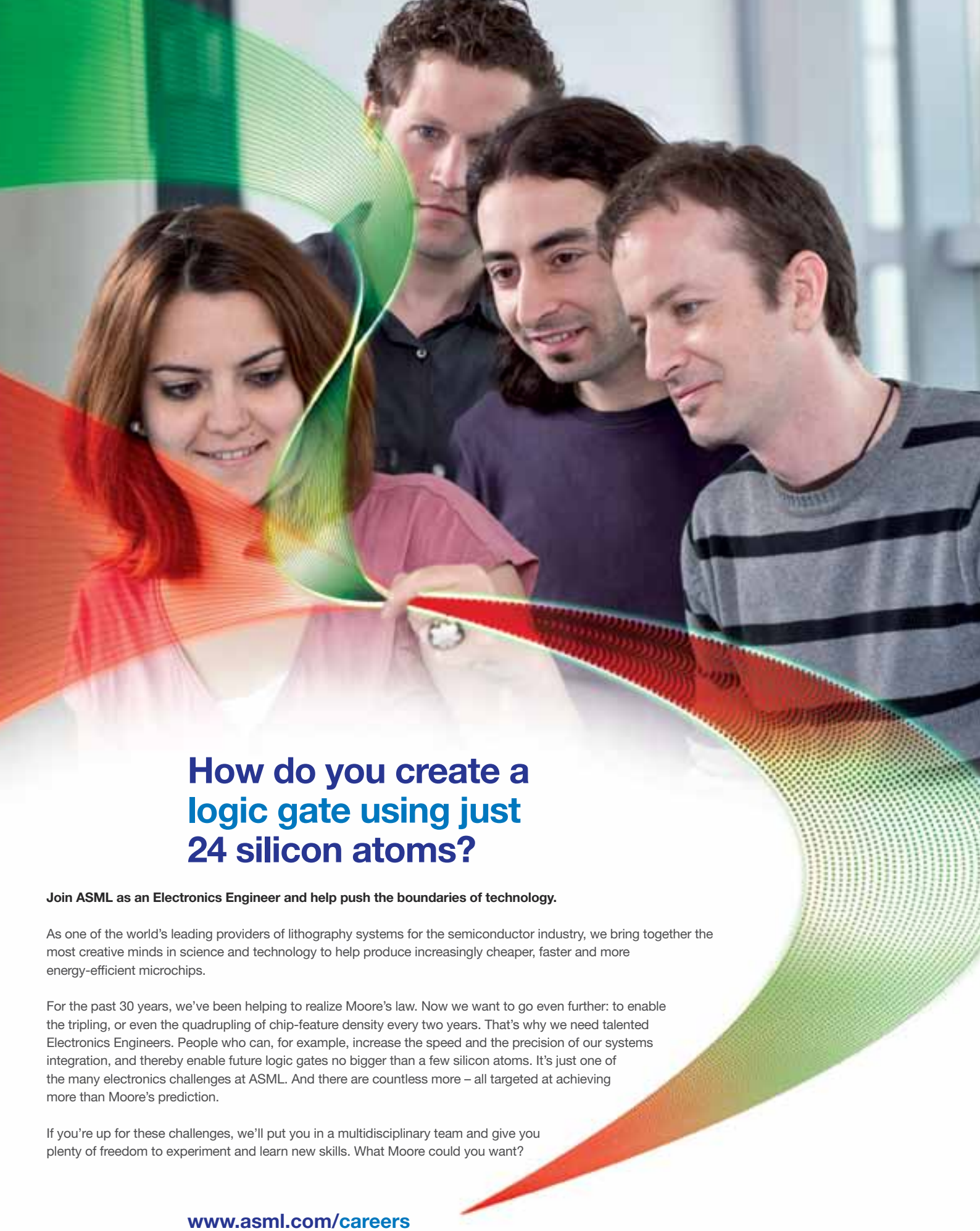
Truusje got an internship at a small robotics lab, which is built high up ona mountain and is only accessible via a thin rickety bridge. After crossing the bridge, Truusje walks up the path to the facility,. Truusje presses a big red button to open the door, only to find the lab assistant, the janitor and an old professor escaping through the newly created exit. Confused, Truusje follows after them. Once caught up at the bridge the professor thanks her and explains that they are being followed by evil robots. Fortunately, the robots move very slowly, so it will take them a little more than 17 minutes to arrive at the bridge. Unfortunately the group is quite slow as well. Truusje is quite fit and is able to cross the bridge in 1 minute, the lab assistant takes 2 minutes, the janitor takes 5 minutes and the professor takes the longest: 10 minutes. The bridge is only able to hold two people at the same time, and since it's the middle of the night, a light needs to be used to prevent them from falling through. Truusje is the only one who brought a flashlight with her, which means that there is always someone who needs to return the flashlight to the rest of the group. Having one flashlight also means that two people crossing the bridge will have the speed of the slowest person of the pair. The moment the robots arrive at the bridge, everyone needs to be on the other side. One of these robots weighs a few times the weight of a human body, so the bridge would collapse almost instantly under their weight. The bridge is the only way to get to safety and if it were to collapse with someone on it, there would be no chance of survival. Is it possible for the crew to survive and how would they be able to do it?

In her spare time, Truusje, who has green eyes, is the absolute dictator of a small island nation with a population of 100 people with blue eyes and 100 people with brown eyes.

Fortunately, every day a ferry arrives from the main land, giving the islanders a means to do so. To prevent her subjects from leaving the island, Truusje imports robots from the mainland that guard the ferry day and night. These robots will only allow people with blue eyes to pass. If you approach the robots without the correct eye colour, you will be liquidated on the spot. Unfortunately, the islanders do not know their own eye colour and therefore don't want to risk their lives. The island is completely purged of all reflective objects and the water is too polluted to function as a mirror. The islanders are also unable to communicate. They are not allowed to speak, are illiterate, and don't know any other form of communication. Any developments of communication are suppressed by the government. In short, there is no way to find out your own eye colour by looking at yourself or communicating with others. Every islander is able to see each other's eye colour, but because of these rules, no one knows their own eye colour.

Truusje notices her people are getting angry and in fear of a revolution, she decides to give one hint. She forces her subjects to attend the announcement and gives the following statement: "I can see someone who has blue eyes".

Because of this hint, assuming all islanders are amazing at logic puzzles and assuming the islanders only leave when they are sure they have blue eyes, how many islanders left on which day (so 1 on day 1, 6 on day 2, 87 on day 3, etc.) and why?



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