Paving the whole path – Teaching Embedded Systems from Theoretical Foundations to Interdisciplinary Team Skills

Application to the *Informatics Europe Curriculum Award 2012*

From: **Department of Computer Science** (Fachgruppe Informatik)
RWTH Aachen University, Germany
(Submission on behalf of the department)

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Description of the Achievements

1. Introduction

Embedded systems development in industry is mostly performed by interdisciplinary teams usually consisting (at least) of experts in the application domain (e.g., automotive engineers), of control engineers, of hardware and software experts. The role of Computer Science (CS) graduates in such teams is rapidly shifting from merely an implementing activity to an integrating, often central systems engineering position with an emphasis on architecting, modeling and validation activities. To be successful, our graduates are increasingly expected to have a strong background in model-based, often rigorous design and analysis approaches, as well as being able to communicate efficiently with the domain, control engineering, and hardware experts.

To prepare for these demands, the Computer Science Department at RWTH Aachen University developed a tailored curriculum for embedded systems teaching. The focus of this curriculum is to teach the different disciplines together with their interconnections from the first semester on. This way the students do not get a tunnel vision for each single discipline, but from an early stage on remain aware of the context, chances and boundaries of each single area. This approach reaches over both, the Bachelor and Master program in CS and consists of the three phases illustrated in Figure 1.

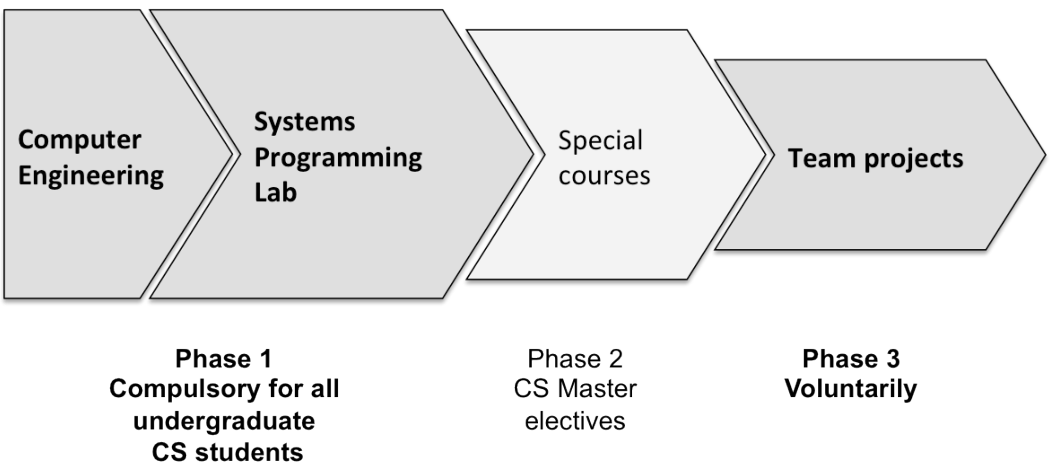


Figure 1: Phases of the embedded computing curriculum

The first phase provides the fundamentals of embedded computing which every CS student should know. It consists of the lecture *Computer Engineering* and a lab course in *Systems Programming*. Both courses are compulsory for CS Bachelor students (about 350 per year). The second phase allows Master students interested in embedded systems to delve into selected embedded systems topics. In the final phase, the students have the possibility to join interdisciplinary teams which take part in competitions organized by third parties. For example, student teams developed autonomously driving scaled cars, unmanned micro air vehicles and a system for intelligent routing of electric wheelchairs.

2. Details of the Phases

2.1 Phase 1: Fundamentals of Embedded Computing

The course **Computer Engineering** (German “Technische Informatik”)) is offered in the first semester. Unlike standard courses with this name, it integrates topics from Computer Architecture with topics from Physics and Electrical Engineering. This makes it possible to link the introduction of basic mathematical and architectural concepts (e.g., latches, arithmetic functions, digital analog converters) with the corresponding electronic realizations and their physical explanations. Our experience is that this integration improves the motivation of CS students to study the physical and electrical engineering basics of computing compared to teaching this in a separate course.

The **Systems Programming Laboratory** is offered in both summer and winter term, and the students can choose to take it between the second and fourth semester. Passing Computer Engineering is a requirement. While Computer Engineering covers theoretical and practical concepts of semiconductor components and microcontrollers, the Systems Programming Laboratory focuses on their application. The laboratory course consists of six parts, during which the students finally have to implement an operating system for a customized microcontroller board. First, they have to complete a design of customized board. Then the different components of a small operating system (scheduler, memory management, etc.) must be implemented. The laboratory takes place each two weeks and consists of six dates – one for each part. Between these dates, a number of time slots is offered in which the students have access the laboratory room and can try their designs, accompanied by two advisors. Figure 2 provides impressions from the laboratory room, one of the workplaces and the customized boards.

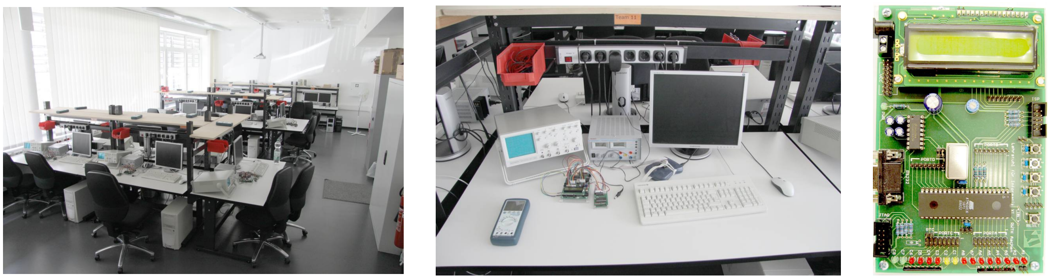


Figure 2: Impressions from the Systems Programming Laboratory

Additionally, the students have the possibility to test their designs from home remotely through the Internet. For this purpose, 15 remote workplaces are provided, each with a webcam, the customized hardware and access to all parts through a specific web interface. Figure 3 shows the setup of the remote workplaces.

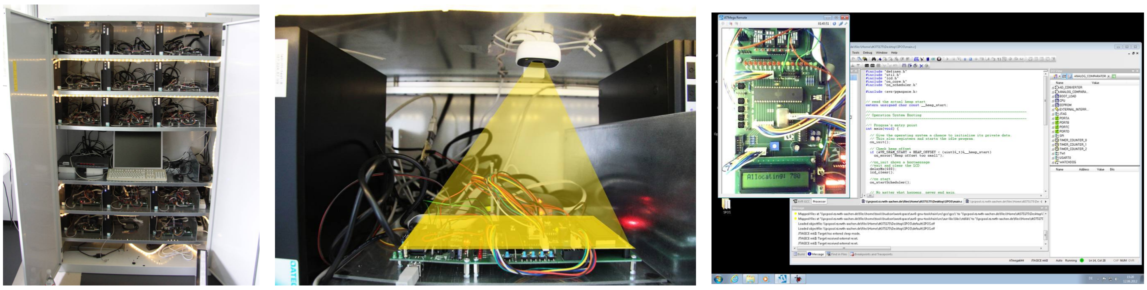


Figure 3: Remote Access to the Systems Programming Laboratory

The two courses from this first phase are complemented with standard courses like Operating Systems or Data Communication, as they can be found in most CS curricula.

2.2 Phase 2: Specialization in embedded systems specific topics

In this phase, students who continue to the Master program and who decide to specialize in embedded systems, can take several elective courses in the area of embedded systems. As these courses probably are not different from most courses of this kind, we only briefly list them:

Introduction to Embedded Systems gives a broad introduction to the field. The topics of the lecture are embedded computing platforms (microcontrollers, programmable logic controllers, programmable hardware, and Android as a mobile embedded computing platform), real-time systems, scheduling, communication busses for embedded systems, and embedded software engineering.

Safety and Reliability of Software-controlled Systems introduces basic reliability measures, models and analysis methods (e.g., fault tree analysis, FMEA, Markov models) and gives an introduction to the design of safety-related systems according to IEC 61508.

Dynamic Systems for CS students introduces continuous dynamic systems theory and control theory to computer science students. Topics are, for example, linear systems, state space representation, and controller design. The aim of his course is to enable the students to competently communicate with control engineers.

Formal Methods for Embedded Systems introduces various formal methods and their application in the area of embedded systems. The formal methods include abstract interpretation, model-checking and static analysis. The methods are applied to different models: automata, timed automata, hybrid automata, assembly-code, and C-code.

2.3 Phase 3: Team projects

In the final phase, we encourage students to take part in student projects. Our experience is, that it is most motivating for the students, if the participation in the projects is voluntary and not connected to a study obligation. In the following we present three examples.

Team GalaXIs is a student group participating in the Carolo-Cup contest, organized by the University of Brunswick, Germany. In this contest, student groups develop and implement autonomously driving model cars in a 1:10 scale, taking into account costs and energy efficiency. The challenge is to have the best possible car control in various scenarios, which are derived from requirements of real-world scenarios. The annual contest allows the students to present their skills to a jury of experts from science and industry and to challenge other teams. During the competition, specific tasks have to be accomplished as quick and accurate as possible. Additionally each team has to present the specific features of their concept and implementation during a presentation session.

Team GalaXIs consists of 5-8 students from different disciplines: computer science, mechanical and electrical engineering. The students have a dedicated room for working on their hardware and a separate test track to test the car. In the last four years the team from the Embedded Software Laboratory won the contest twice and also reached the second place twice. Figure 4 shows the work shop, one car and the test track.

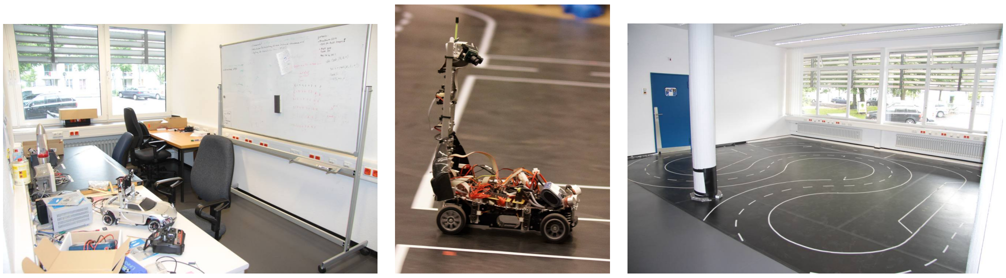


Figure 4: GalaXIs' workshop, car, and test track

The **MAVerix-Team** is a student team participating in the International Micro Air Vehicle Conference and Flight Competition (IMAV). To enter the competition, each student team has to develop and implement a complete model plane by itself. This includes the design of the plane as well as the software on board. Goal of the competition is to acquire as many points as possible in different flight missions. Some missions are: efficient endurance flight, touch a balloon, flight through arch, starting and landing. Additionally there are different levels of autonomy. The goal is to have a full-autonomous plane. In this case the team gets the most points for a mission. The missions are separated into indoor- and outdoor-missions. The MAVerix-Team participates in the outdoor competition part.

To combine the necessary expertise required by the competition mission statements, the team consists of students from the following disciplines: electrical engineering, computer science, computer vision, flight and mechanical engineering. All students work together in one team of 8-12 students. The various system components are so intertwined, that nearly all subtasks are done by at least one student of each institute and the whole team meets at least once per week to discuss multidisciplinary challenges. This way the different tasks, like flight control, autonomy, image recognition and sensor fusion can be treated with the necessary expert knowledge. The students learn to speak with team colleagues from other disciplines and to handle interdisciplinary issues. The team is working on a tilt-wing concept, which is able to switch during flight between horizontal and vertical flight mode. Figure 5 gives impressions of the last IMAV and the tilt wing plane.

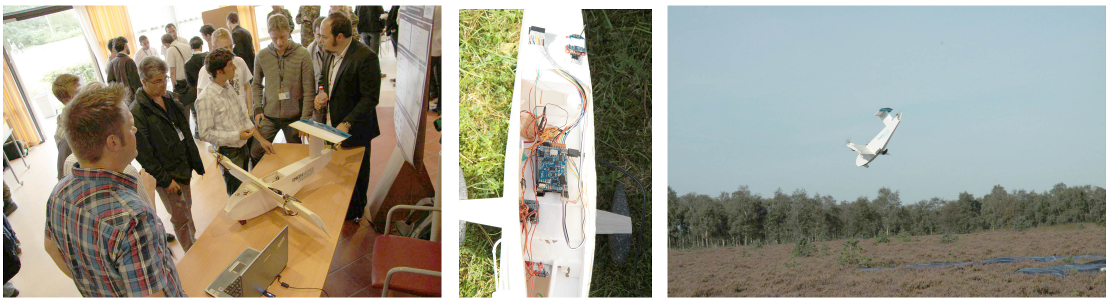


Figure 5: Impressions from IMAV

In the **eNav-Team**, students work on intelligent routing of electric wheelchairs using topological properties, like incline and boarding information to compute the most efficient route to a destination. This project consists of two parts. The first part addresses the hardware of the electric wheelchair. Since the sensors for checking the battery level of current electric wheelchairs are not very accurate, electrical engineering students work together with computer science students on combining different sensors with self-designed customized hardware to improve the accuracy of the battery level information. Through a Bluetooth module on this self-designed customized hardware, the current battery status is reported to a mobile device (Android, iOS, J2ME, ...) and used in the second part of the project.

Figure 6: Two team members and the wheelchair, and the routing interface

The second part deals with the navigation system for electric wheelchairs. Such a navigation system can not only compute the shortest and fastest route, but also the most efficient with respect to energy consumption of electric wheelchairs. Together with the accurate information about the current battery level, this self-developed algorithm can tell the driver of an electric wheelchair, if he or she can accomplish the planned route with the current battery level. The students have to work with the battery sensor components, realize communication tasks between the wheelchair and mobile device with the navigation system, and perform various software design tasks on the level of the mobile device: Implementing the modified algorithm, integrating OpenStreetMap, dealing with databases, etc.

3. Conclusion

The presented concept in embedded computing education is neither a full study program in embedded systems nor the curriculum of a single course. Instead, it is rather a frame around a standard CS curriculum, starting and ending with unconventional lectures, laboratory courses and student projects. As such, we believe it is new style of curriculum in embedded computing. Our experiences are very good, considering the feedback from students and from companies which hired students who went this path (see the evidence of impact). We also received positive feedback from the embedded systems education community to which we have been publishing about this concept regularly (see References).

Evidence of Availability of the Curriculum's Materials to the Teaching Community

1. Availability to students

All students of the RWTH Aachen University can access all material of the lectures in which they participate using their university login. The material is then available to the students through the *L2P – Learning and Teaching Portal of RWTH Aachen* (see http://www2.elearning.rwth-aachen.de/english). This material includes video recordings (slides, annotations and soundtrack) from all lectures.

2. External availability

Exactly the same information as for the students at RWTH Aachen is also available for the external teaching community via the web site

http://embedded.rwth-aachen.de/doku.php?id=en:resources:embeddedcomputing

The information there is structured as follows:

- Computer Engineering
    - **All exercise sheets**
    - Lecture
        - **All lecture slides**
        - **All lecture videos**
- Systems Programming Laboratory
    - **All laboratory exercise descriptions**
- Dynamic Systems
    - **All exercise sheets**
    - Lecture
        - **All lecture slides**
        - **All lecture videos**
- Formal Methods for Embedded Systems
    - **All exercise sheets**
    - **All lecture slides**
- Introduction to Embedded Systems
    - **All exercise sheets**
    - Lecture
        - **All lecture slides**
        - **All lecture videos**
- Safety and Reliability of Software Controlled Systems
    - **All exercise sheets**
    - Lecture
        - **All lecture slides**
        - **All lecture videos**

Reference List

Publications about the **Systems Programming Laboratory**:

- Stollenwerk, A., Derks, A., Kowalewski, S., and Salewski, F., "A Modular, Robust and Open Source Microcontroller Platform for Broad Educational Usage", *in Proc. Workshop on Embedded Systems Education (WESE'10)*, Scottsdale, AZ, USA, 2010, ACM, pp. 48-54.
- Stollenwerk, A., Jongdee, C., and Kowalewski, S., "An Undergraduate Embedded Software Laboratory for the Masses", in *Proc. Workshop on Embedded Systems Education (WESE'09)*, Grenoble, France, New York, NY, USA, 2009, ACM, pp. 34-41.
- Salewski, F. and Kowalewski, S., "Hardware Platform Design Decisions In Embedded Systems - A Systematic Teaching Approach", in *Proc. Special Issue on the Second Workshop on Embedded System Education (WESE'06)*, 2007, vol. 4, ACM, pp. 27-35.
- Salewski, F., Wilking, D., and Kowalewski, S., "Diverse hardware platforms in embedded systems lab courses: A way to teach the differences", in *Proc. Special Issue: The First Workshop on Embedded System Education (WESE'05)*, 2005, vol. 2, ACM, pp. 70-74.

References related to **team GalaXIs**:

- Various appearances in television and radio and press releases (mostly in German), see: http://galaxis.rwth-aachen.de/?mediathek.html

Publications resulting from the **MAVerix team**:

- Gathmann, F., Dernehl, C., Franke, D., and Kowalewski, S., "An integrated vision aided GPS/INS Navigation System for ultra-low-cost MAVs", in *Proc. International Micro Air Vehicle Conference (IMAV)*, 2012, IMAV, To appear.
- Dernehl, C., Franke, D., Diab, H., and Kowalewski, S., "An Architecture with Integrated Image Processing for Autonomous Micro Aerial Vehicles", in *Proc. International Micro Air Vehicle Conference 2011 (IMAV 2011)*, 2011, IMAV, pp. 138-145.
- Television report about team MAVerix (in German): http://youtu.be/QURuZEQK3AE

Publications and references resulting from the **eNav project** (all in German):

- Franke, D., Dzafic, D., Weise, C., and Kowalewski, S., "Entwicklung eines mobilen Navigationssystems für Elektrofahrzeuge auf Basis von OpenStreetMap-Daten", in *Proc. Konferenz für Freie und Open Source Software für Geoinformationssysteme (FOSSGIS 2011)*, 2011, FOSSGIS e.V., pp. 92-99.
- Franke, D., Dzafic, D., Weise, C., and Kowalewski, S., "Konzept eines Mobilen OSM-Navigationssystems für Elektrofahrzeuge", in *Proc. Angewandte Geoinformatik 2011 - Beiträge zum 23. AGIT-Symposium (AGIT 2011)*, 2011, Wichmann Verlag, pp. 148-157.
- Various reports in television, radio and press releases, see: http://embedded.rwth-aachen.de/doku.php?id=lehrstuhl:pressespiegel

Evidence of Impact

1. Results and certificates from the GalaXIs team participation at the Carolo-Cup contest (in German)

2. Press reports on the eNAV project (in German)

3. The most recent student evaluations for the courses

    a. Introduction to Embedded Systems ("Einführung in eingebettete Systeme", partly in German)

    b. Systems Programming Lab ("Systemprogrammierung", in German)

    c. Computer Engineering ("Einführung in die Technische Informatik", in German)

Unfortunately, all relevant documents are in German. We hope that the main information can still be retrieved from them.

„Carolo-Cup“ 2008

Carolo-Cup

1 Endergebnisse

1.1 Gesamt

Team	Hochschule	HeB	EPK	SFKmA	EP	RSoH	RSmH	Punkte	Platz
GalaXIs	RWTH Aachen	40	118	109	**200**	**200**	**250**	**917**	1
CDLC	TU Braunschweig, IFR	43	141	148	0	54	151	537	2
Fredt	TU Braunschweig, ILF	**50**	124	98	0	96	151	519	3
Marvin	TU Braunschweig	40	87	75	71	80	136	489	4
Faust	HAW Hamburg	0	**150**	**150**	0	52	0	352	5
Leda	Jacobs University Bremen	0	87	91	0	0	0	178	6

Abkürzungen:

HeB	Herstellungskosten und Energiebilanz
EPK	Einparkkonzept
SFKmA	Spurführungskonzept mit Ausweichen
EP	Einparken
RSoH	Rundstrecke ohne Hindernisse
RSmH	Rundstrecke mit Hindernissen

1.2 Herstellungskosten und Energiebilanz

Team	Hochschule	Punkte	Platz
Fredt	TU Braunschweig, ILF	50	1
CDLC	TU Braunschweig, IFR	43	2
GalaXIs	RWTH Aachen	40	3
Marvin	TU Braunschweig	40	3
Faust	HAW Hamburg	0	5
Leda	Jacobs University Bremen	0	5

1.3 Einparkkonzept

Team	Hochschule	Punkte	Platz
Faust	HAW Hamburg	150	1
CDLC	TU Braunschweig, IFR	141	2
Fredt	TU Braunschweig, ILF	124	3
GalaXIs	RWTH Aachen	118	4
Leda	Jacobs University Bremen	87	5
Marvin	TU Braunschweig	87	5

Carolo-Cup

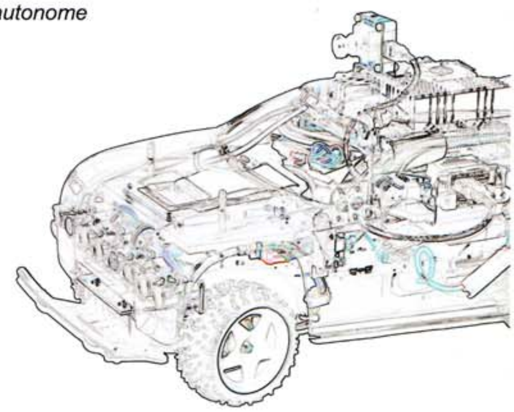
Urkunde

CAROLO-WILHELMINA BRAUNSCHWEIG

Carolo-Cup Hochschulwettbewerb

Studenten entwickeln autonome Modellfahrzeuge

10. Februar 2009



Philipp Fischer

hat erfolgreich teilgenommen.

Veranstalter
TU Braunschweig
VDE/VDI

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Carolo-Cup

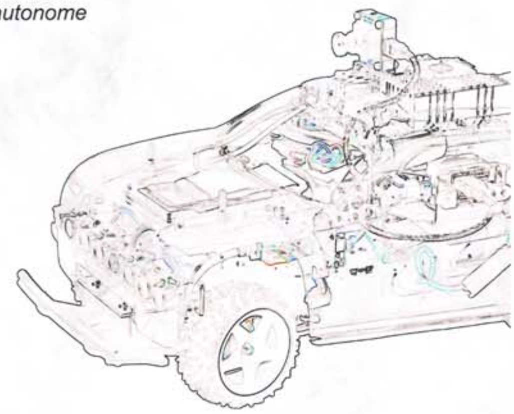
Urkunde

CAROLO-WILHELMINA BRAUNSCHWEIG

Carolo-Cup Hochschulwettbewerb

Studenten entwickeln autonome Modellfahrzeuge

9. Februar 2010



Matthias May

hat erfolgreich mit dem 1. Platz teilgenommen.

Veranstalter
TU Braunschweig
VDE/VDI

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Technische Universität Braunschweig

Carolo-Cup

Urkunde

Beim **Hochschulwettbewerb Carolo-Cup 2011**

– Studenten entwickeln autonome Modellfahrzeuge –

hat **Matthias May** mit **Team GalaXIs**
den 2. Platz belegt.

Veranstalter: Technische Universität Braunschweig & *VDE / VDI*
Braunschweig, den 8. Februar 2011

Prof. Dr. Thomas Form · Prof. Dr. Ulrich Seiffert · Prof. Dr. Markus Maurer

Schirmherrschaft: VDE · VDI

Partner: BOSCH Technik fürs Leben · carmeq · Continental · TÜV SÜD · Automotive Safety Technologies · IAV GmbH · Infineon · eck*cellent IT

Dzenan Dzafic und Dominik Franke entwickelten einen energiesparenden Routenplaner für Elektrorollstuhlfahrer. Foto: Peter Winandy

Navigation für Elektrorollstühle

Oft reicht der Akku seines Rollstuhls nicht für die Fahrt zur Hochschule und wieder zurück nach Hause. Dzenan Dzafic studiert Informatik an der RWTH. Er nutzte sein hier erworbenes Wissen und entwickelte ein mobiles Navigationssystem für Elektrorollstühle: „Fahrzeuge mit Elektromotoren sind in ihrem Bewegungsraum durch die Akku-Kapazität und den Stromverbrauch eingeschränkt. Der Stromverbrauch ist stark abhängig von der Steigung und dem Straßenbelag. Je größer die zu bewältigende Steigung und je unebener der Belag ist, desto schneller sinkt der Akkustand“, erklärt Dzafic.
Zusammen mit Diplom-Informatiker Dominik Franke, wissenschaftlicher Mitarbeiter am Lehrstuhl für Informatik 11 (Software für eingebettete Systeme), entwickelte er einen Algorithmus auf Basis von Daten aus der OpenStreetMap, kurz OSM. Sie gingen dabei davon aus, dass ein kurzer Weg nicht immer effizient sein muss: „Auch wenn ich laut Plan schneller an einem Ort sein könnte, kann ich wegen vieler Steigungen auf halber Strecke nicht mehr weiterkommen“, berichtet Dzafic. Mit Hilfe der neuen Daten soll der Energieverbrauch einer Route angezeigt und damit die Reichweite des Fahrzeugs maximiert werden.
Noch gibt es wenige Systeme, die den Akkustand zu Beginn der Route, die Steigung des Streckenverlaufs und mögliche Ladestationen für Elektrofahrzeuge berücksichtigen. Die frei verfügbare Weltkarte OSM war Ausgangspunkt für den am RWTH-Lehrstuhl unter Leitung von Professor Dr.-Ing. Stefan Kowalewski entwickelten Rollstuhl-Routenplaner. Durch die freie und kostenlose Nutzbarkeit bietet OSM den Vorteil, dass die Benutzer Informationen in die Karte eingeben können. „Hier sind bereits mehrere Teile Deutschlands erfasst“, so Franke. „In Aachen basieren die Daten auf meinen Erfahrungswerten“, ergänzt Dzafic.

Zusammenarbeit mit Exzellenzcluster UMIC
Um die Akku-Kapazität eines Rollstuhls zu bestimmen, umfuhr der 29-Jährige mit speziellen Sensoren am Rollstuhl immer wieder den Sportplatz des Hochschulsportzentrums. „Die Strecke ist besonders ebenmäßig und eignete sich daher gut für die Messungen. Es dauerte vier Stunden, bis der Akku leer war“, berichtet Dzafic. Danach testeten die beiden Informatiker verschiedene Steigungen in Aachen, die maximale Bordsteinhöhe, die Straßenbeschaffenheit und das Gefälle wurden ebenfalls berücksichtigt. Mit Hilfe dieser Messungen und den Daten aus OSM berechneten sie eine effiziente und eine kurze Route. Dem Nutzer werden künftig beide Wege sowie der Energieverbrauch angezeigt. „Unser Routenplaner kann bei einer Strecke von 300 Metern bis zu 20 Prozent der Energie einsparen“, so Franke.
In Zusammenarbeit mit dem Exzellenzcluster UMIC (Ultra high-speed Mobile Information and Communication) Research Centre der RWTH und der Universität Heidelberg konnte der Algorithmus in den Webservice www.rollstuhlrouting.de integriert und zusätzlich um den mobilen Client AndNav für die Plattform Android erweitert werden. Somit ist die Route auch per Mobiltelefon abrufbar. Mit seiner Anwendung hat Dzafic dabei nicht nur großes Interesse bei Betroffenen geweckt, auch viele Wissenschaftler nahmen Kontakt auf. Das Projekt soll nun auf verschiedene Formen der Elektromobilität ausgedehnt werden.

Informationen gibt Diplom-Informatiker Dominik Franke unter 0241/80-21172 oder franke@embedded.rwth-aachen.de.

Celina Begolli

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11.01.2012 - 17:01 Schrift 2 Bilder 0 Kommentare

Routenplaner für Rollstuhlfahrer

Ein mobiles Navigationssystem für Elektrorollstühle hat Informatikstudent Dzenan Dzafic an der RWTH Aachen entwickelt. Ausgangspunkt war die Erkenntnis, dass Fahrzeuge mit Elektromotoren in ihrem Bewegungsspielraum durch die Akku-Kapazität und Stromverbrauch stark eingeschränkt sind.

Letztere sei stark abhängig von Steigungen und Straßenbelag der Strecke. Daraus ergab sich auch die Einsicht, dass ein kurzer Weg nicht immer effizient sein muss.

Die frei verfügbare Weltkarte OpenStreetMap (OSM) war Ausgangspunkt für den Rollstuhl-Routenplaner, bei dem Benutzer Informationen eingeben können. Dort sind bereits mehrere Teile Deutschlands erfasst. "In Aachen basieren die Daten auf meinen Erfahrungswerten", so Dzafi. Mit Hilfe von Messungen der Akkukapazität, maximaler Bordsteinhöhen, der Straßenbeschaffenheit und Steigungen sowie den Daten aus OSM wurde eine effiziente und eine kurze Route berechnet. Dem Nutzer werden beide Wege sowie der Energieverbrauch angezeigt. "Unser Routenplaner kann bei einer Strecke von 300 Metern bis zu 20 Prozent der Energie einsparen helfen", so Diplom-Informatiker Dominik Frank, wissenschaftlicher Mitarbeiter.

In Zusammenarbeit mit dem Forschungszentrum UMIC (ultra high-speed mobile Information and Communication) der Rheinisch-Westfälischen Technischen Hochschule Aachen und der Universität Heidelberg konnte der für die Anwendung entwickelte Algorithmus in den Webservice www.rollstuhlrouting.de integriert werden. Zusätzlich wurde er um den mobilen Client AndNav für die Plattform Android erweitert. Somit ist die Route auch für Mobiltelefone abrufbar.

Das Interesse von betroffenen und vielen Wissenschaftlern ist groß. Das Projekt soll nun auf verschiedene Formen der Elektromobilität ausgedehnt werden.

auto.de/(ld/mid)

Einführung in eingebettete Systeme

Lehrveranstaltungsnummer: 11ss-24196
Lehrveranstaltungstyp: Vorlesung/Übung (VÜ)
Erfasste Fragebögen: 35

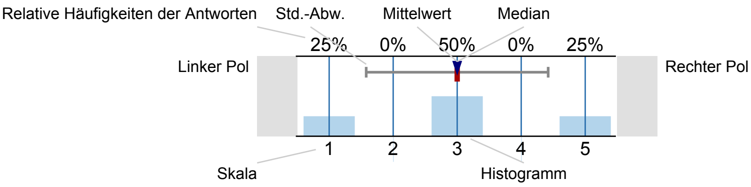
Globalwerte

Globalindikator	- 1 2 3 4 5 +	mw=1.6 s=0.7
Lecture Concept	- 1 2 3 4 5 +	mw=1.6 s=0.8
Exercise Course Concept	- 1 2 3 4 5 +	mw=1.6 s=0.7

Auswertungsteil der geschlossenen Fragen

Legende

Fragetext



n=Anzahl
mw=Mittelwert
md=Median
s=Std.-Abw.
E.=Enthaltung

Personal Details

Gender

female	13.6%	n=22
male	40.9%	
n.s.	45.5%	

Semester

1-2	28.6%	n=35
3-4	22.9%	
5-6	25.7%	
7-8	14.3%	
9-10	5.7%	
above 10	2.9%	

Nationality

Germany (D)	66.7%	n=27
EU (excl. D)	3.7%	
Non-EU	29.6%	

Lecture Concept

I realise what the lecture is good for.

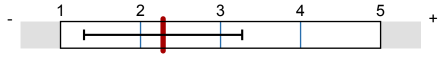
	1	2	3	4	5		
fully applies	44.1%	50%	5.9%	0%	0%	does not apply	n=34 mw=1.6 md=2 s=0.6

Systemprogrammierung

Lehrveranstaltungsnummer: 11ws-11939
Lehrveranstaltungstyp: Praktikum Informatik
Erfasste Fragebögen: 95

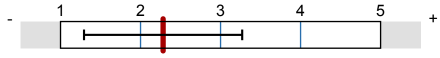
Globalwerte

Globalindikator



mw=2.3
s=1

Angaben zur Lehrveranstaltung

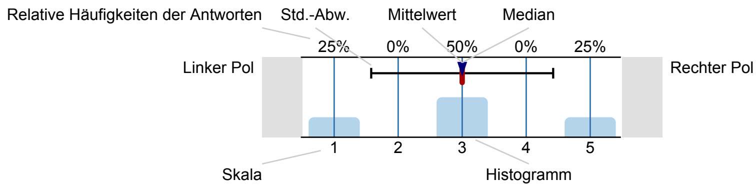


mw=2.3
s=1

Auswertungsteil der geschlossenen Fragen

Legende

Fragetext



n=Anzahl
mw=Mittelwert
md=Median
s=Std.-Abw.
E.=Enthaltung

Angaben zur Person

Geschlecht

n=91

weiblich	5.5%
männlich	90.1%
k.A.	4.4%

Fachsemester

n=93

1-2	0%
3-4	79.6%
5-6	10.8%
7-8	6.5%
9-10	2.2%
über 10	1.1%

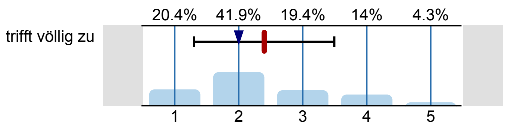
Nationalität

n=87

deutsch (D)	92%
EU (ohne D)	3.4%
Non-EU	4.6%

Angaben zur Lehrveranstaltung

Ich hatte die notwendigen Vorkenntnisse für diese Veranstaltung



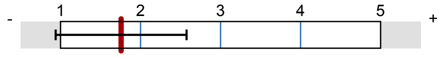
n=93
mw=2.4
md=2
s=1.1

Einführung in die Technische Informatik

Lehrveranstaltungsnummer: 11ws-06038
Lehrveranstaltungstyp: Vorlesung
Erfasste Fragebögen: 227

Globalwerte

Globalindikator



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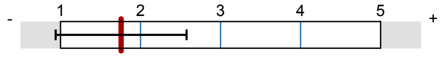
s=0.8

Konzept der Vorlesung

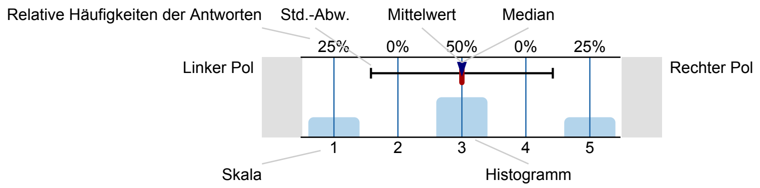


mw=1.8
s=0.8

Auswertungsteil der geschlossenen Fragen

Legende

Fragetext



n=Anzahl
mw=Mittelwert
md=Median
s=Std.-Abw.
E.=Enthaltung

Angaben zur Person

Geschlecht

n=221

weiblich	14.5%
männlich	82.8%
k.A.	2.7%

Fachsemester

n=218

1-2	92.7%
3-4	3.2%
5-6	1.4%
7-8	1.4%
9-10	0.5%
über 10	0.9%

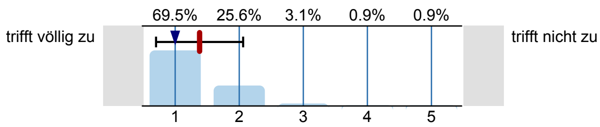
Nationalität

n=208

deutsch (D)	89.4%
EU (ohne D)	3.8%
Non-EU	6.7%

Konzept der Vorlesung

Mir ist klar, wozu die Vorlesung gut ist.



n=223
mw=1.4
md=1
s=0.7
E.=1