international smart home project
– practical part

Course Syllabus

Mixed groups of American and German students are working on several topics around a smart home model of a real house. Several tasks can be controlled and monitored by a smart-phone.
Time and Location

This international German-American smart home project will take place from March until September 2020. Time details are listed below and in the 2020 schedule. The syllabus is adjusted to reflect special circumstances related to the international experience. The tabular schedule is a guideline; we will try to follow it closely, but be prepared to adjust to changes in pace dictated by our collective experience.

Timeline 2020:

March until July
- assigning of German and American students to the sub-projects
- selfstudy and long distance groupwork
- Contact between students via Adobe Connect, Skype etc.
- Literature research, preparation for sub-projects through self-study

July/August
- six weeks in Germany - practical work after basic classes
- Monday July 6th 2020 – Friday August 16th 2020
- at Jade University of Applied Sciences in Wilhelmshaven

August/September
- two weeks long distance groupwork, documentation

September
- last week final project work at TTU
- final presentation of the project results at TTU

Instructors

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E-Mail:
Web:
Office Hours

We can meet after each class or lab for questions or on appointment.
The international smart home project consists of two parts:

- smart home project - theoretical part
- smart home project - practical part

Content of the smart home project - theoretical part

- project management 10% test PB
- open-source electronics platform (Arduino or Raspberry Pi) 10% test TBA
- principles of electrical engineering 10% test PB
- thermodynamics 10% test PB
- electronics, sensorics, control technology 10% test JT
- power electronics 10% test FR
- presentation technology VL
- final presentation 40% JT, PB, TBA, VL
**Content of the smart home project – practical part**

Sub-projects, student chooses one out of five:

<table>
<thead>
<tr>
<th></th>
<th>Sub-project</th>
<th>Prerequisite</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>heating pool</td>
<td>smart home project - theoretical part - branch ENGINEERING</td>
</tr>
<tr>
<td>B</td>
<td>app development</td>
<td>smart home project - theoretical part - branch INFORMATICS</td>
</tr>
<tr>
<td>C</td>
<td>elevator</td>
<td>smart home project - theoretical part - branch ENGINEERING</td>
</tr>
<tr>
<td>D</td>
<td>photovoltaics</td>
<td>smart home project - theoretical part - branch ENGINEERING</td>
</tr>
<tr>
<td>E</td>
<td>optical movement and shape recognition</td>
<td>smart home project - theoretical part - branch INFORMATICS</td>
</tr>
</tbody>
</table>
This syllabus is for the **international smart home project - practical part**!

### Catalog Description and Prerequisites

American and German students will participate in an international project. Mixed student groups are working together in a laboratory. The Student will work on his assigned sub-project.

Prerequisites: Classes of the related international smart home project - practical part.

Possible sub projects (student chooses one out of five A - E):

**A: heating pool**

prerequisite: smart home project - theoretical part - branch ENGINEERING

description:

** Supervisors**
Paul Beckmann, Josef Timmerberg

**Detailed description of the topic**

The basis of the ISRP is to automate a two-story flat roof residential building on a scale of 1:10. The automation task is split into subprojects. Group A's job is to control the water temperature in the outdoor pool. Different power controllers and controller strategies are to be tested. For state-of-the-art controls, operation should also be possible via mobile phone.

**Previous preparation in USA and D (Literature you can get in Moodle)**

- Manfred Schleicher, Frank Blasinger; Control Engineering, A guide for beginners
- Prof. Pohl, Reglerentwurf, FH Bochum

**Plan of procedures**

<table>
<thead>
<tr>
<th>subgroup 1 (2 students)</th>
<th>subgroup 2 (2 students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• measure the step function response of the control process (without the module of subgroup 2)</td>
<td>• analyse an existing phase controlled modulator for the pool heating</td>
</tr>
<tr>
<td>• build the mathematical model from the step function response</td>
<td>• simulate the circuit with LT-Spice</td>
</tr>
<tr>
<td>• simulate (Scilab, Xcos) the control process with the mathematical model</td>
<td>• test the existing hardware</td>
</tr>
</tbody>
</table>

- analyse an pulse packet controller for the pool heating
- simulate the circuit with LT-Spice
- test the existing hardware

- control unit design (with the math. model and the frequency response characteristic)
- simulation of the overall system
- programming the controller with Arduino
- measure the step function response of the overall system and make the presentation and a movie
- create the mathematical model with physical knowledge and compare it with that of measurement
- calculate the frequency response characteristic from the step function response
- simulate (Scilab, Xcos) the control process with the mathematical model and the frequency response characteristic
- create the presentation and documentation and make a movie

**Hardware needed**

After the introductory lessons in project overview and project management, the students should work out which hardware extensions such as sensors or actuators or ... they additionally need.

**Software needed**

In the same way as with the hardware extensions, they should work out whether and, if so, which additional software tools have to be procured.

**Examinations and Presentations**

Each group will have an internal, non-graded final presentation in Wilhelmshaven together with a person who will be the assistance in Wilhelmshaven during the presentations in Lubbock.

During the second distance learning time, Students are requested to finish their report and prepare the final presentation (both graded).

**B: app development**

prerequisite: smart home project - theoretical part - branch INFORMATICS

description:

**Supervisors**

Jan Dierks, Josef Timmerberg

**Detailed description of the topic**

The basis of the ISRP is to automate a two-story flat roof residential building on a scale of 1:10. The automation task is split into subprojects. Group B's job is to combine all values gathered by other groups via MQTT in an Unity Application. This Application should also be capable of sending values to other groups.

**Previous preparation in USA and D (Literature you can get in Moodle)**

- Unity Beginner Tutorial (Sections 1 and 2): https://unity3d.com/learn/beginner-tutorials
- Unity Tutorial on User Interfaces: https://unity3d.com/learn/tutorials/s/user-interface-ui
- Unity Tutorials on Scripting: https://unity3d.com/learn/tutorials/s/scripting
- MQTT: https://www.hivemq.com/mqtt-essentials/

**Plan of procedures**

- Draw a possible interface consisting of User Interface components (2D)
- Develop possible scenes, keep them as generic as possible
- Research a suitable MQTT Library

<table>
<thead>
<tr>
<th>subgroup 1</th>
<th>subgroup 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Build interface for 2 other groups (Elevator and Object Detection / Movement)</td>
<td>• Build interface for 2 other groups (Pool Heating and Photovoltaic)</td>
</tr>
<tr>
<td>• ask them for possible in- and outputs</td>
<td>• ask them for possible in- and outputs</td>
</tr>
<tr>
<td>• Add word recognition</td>
<td>• Build an interface which is able to display developments over time</td>
</tr>
</tbody>
</table>
• split source code in reusable functions
• document source code
• document use cases and program in one (or more) Flowcharts
• create the presentation and documentation and make a movie

Hardware needed
There is no special hardware needed.

Software needed
This Group needs installed personal (free) versions of Unity.

Examinations and Presentations
Each group will have an internal, non-graded final presentation in Wilhelmshaven together with a person who will be the assistance in Wilhelmshaven during the presentations in Lubbock.

During the second distance learning time, Students are requested to finish their report and prepare the final presentation (both graded).

C: elevator
prerequisite: smart home project - theoretical part - branch ENGINEERING
description:

Supervisors
Paul Beckmann, Jan Dierks

Detailed description of the topic
The basis of the ISRP is to automate a two-story flat roof residential building on a scale of 1:10. The automation task is split into subprojects. Group C's job is to control the external elevator attached to the house.

Previous preparation in USA and D (Literature you can get in Moodle)
  - How stepper motors and drivers work
  - Study possible types of sensors for floor detection and emergency stop
  - MQTT: https://www.hivemq.com/mqtt-essentials/

Plan of procedures
• Research on different elevator dispatch mechanism
• Summarize possible sequences
• Control the motor using an Arduino
• Use Sensors to locate the elevator
• Add security features
• Broadcast values via MQTT
• Add buttons and displays
• document source code
• document use cases and program in one (or more) Flowcharts
• create the presentation and documentation and make a movie
Hardware needed
The elevator is moved by a nema17 motor, which needs a driver board and an Arduino to control it. Students have to decide, which sensors are suitable and how security mechanism can be implemented.

Software needed
This Group needs Android IDE.

Examinations and Presentations
Each group will have an internal, non-graded final presentation in Wilhelmshaven together with a person who will be the assistance in Wilhelmshaven during the presentations in Lubbock.

During the second distance learning time, Students are requested to finish their report and prepare the final presentation (both graded).

D: photovoltaics
prerequisite: smart home project - theoretical part - branch ENGINEERING
description:

Supervisors
Josef Timmerberg, Paul Beckmann

Detailed description of the topic
The basis of the ISRP is to automate a two-story flat roof residential building on a scale of 1:10. The automation task is split into subprojects. Group D’s job is to supply the house with renewable energy by a PV system. The renewable energy system should consist of the solar module, an accumulator and a controller, which also contains an mpp-tracker. For state-of-the-art controls, operation should also be possible via mobile phone.

Previous preparation in USA and D
- Wiki: https://en.wikipedia.org/wiki/Maximum_power_point_tracking
- https://forum.allaboutcircuits.com/threads/12v-battery-solar-charger.45814/page-2
- https://de.wikipedia.org/wiki/Maximum_Power_Point_Tracking
- https://de.wikipedia.org/wiki/Photovoltaikanlage

Plan of procedures
- plan the energy supply of the house model – energy independent / grid independent
- create an energy supply with "normal" components: PV panel, battery, ..
- measure the characteristic curves I(U) and P(U) of the PV panels
- dimension the battery
- create a concept of a mpp-controller

<table>
<thead>
<tr>
<th>subgroup 1</th>
<th>subgroup 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>analyse the existing control hardware and the existing mpp tracker with LT-Spice and test it</td>
<td>develop the software for the Arduino</td>
</tr>
<tr>
<td>join the hardware and the software</td>
<td>test the software with the simulation of the PV-panel</td>
</tr>
<tr>
<td>test the whole system, draw characteristic curves</td>
<td>create the presentation and documentation and make a movie</td>
</tr>
</tbody>
</table>
Hardware needed
After the introductory lessons in project overview and project management, the students should work out which hardware extensions such as sensors or actuators or ... they additionally need.

Software needed
In the same way as with the hardware extensions, they should work out whether and, if so, which additional software tools have to be procured.

Examinations and Presentations
Each group will have an internal, non-graded final presentation in Wilhelmshaven together with a person who will be the assistance in Wilhelmshaven during the presentations in Lubbock.

During the second distance learning time, Students are requested to finish their report and prepare the final presentation (both graded).

E: optical movement and shape recognition
prerequisite: smart home project - theoretical part - branch INFORMATICS
description:

Supervisors
Josef Timmerberg, Jan Dierks, Lingyu Qiu

Detailed description of the topic
The basis of the ISRP is to automate a two-story flat roof residential building on a scale of 1:10. The Optical task is split into subprojects. Group E1's job is to signal, if any person or animal is in the garden or at the entry door, if nobody is at home. Group E2's job is to signal, if a special car as ambulance or fire truck enters the estate of the house. For state-of-the-art controls, operation should also be possible via mobile phone.

Previous preparation in USA and D (Literature you can get in Moodle)
- ((Literature list is missing, will be submitted later))

Plan of procedures
- configure a Raspberry Pi 3 including a camera
- getting started with Python
- analyse the data from of camera (picture format, compression, origin, ...)
- adjust the resolution by your own procedure and find the optimal value
- practise image processing: colour reduction to grey/b-w
- practise image processing: rotate, translate, mirror, scale, edge detection (if time)
- handle the effect of changing the intensity of illumination - offset reduction
- if necessary: filter methods

<table>
<thead>
<tr>
<th>subgroup 1 (2..3 students)</th>
<th>subgroup 2 (2..3 students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical Movement Recognition</td>
<td>Optical Shape Recognition</td>
</tr>
<tr>
<td>• empirical approach</td>
<td>• practise picture segmentation = thresholding</td>
</tr>
<tr>
<td>• correlation approach</td>
<td>• edge and corner detection such as Canny Edge Detection, Moravec's Corner Detector</td>
</tr>
<tr>
<td>• difference method</td>
<td></td>
</tr>
</tbody>
</table>
AND/OR edge and corner detection such as Sobel Edge Detection, Harris Corner Detector
Hough-Transformation for a straight line

- compare and discuss your results of both groups
- document used methods and program
- create the presentation and documentation and make a movie

**Hardware needed**
After the introductory lessons in project overview and project management, the students should work out which hardware extensions such as sensors or actuators or ... they additionally need.

**Software needed**
In the same way as with the hardware extensions, they should work out whether and, if so, which additional software tools have to be procured.

**Examinations and Presentations**
Each group will have an internal, non-graded final presentation in Wilhelmshaven together with a person who will be the assistance in Wilhelmshaven during the presentations in Lubbock.

During the second distance learning time, Students are requested to finish their report and prepare the final presentation (both graded).

**Textbooks**
Lessons In Electric Circuits, Volume III – Semiconductors; Tony R. Kuphaldt; Fifth Edition, last update March 29, 2009
Control Engineering – A guide for beginners; Manfred Schleicher, Frank Blasinger (free)

Machine to Machine - Protocols:
AMQP: https://www.youtube.com/watch?v=ODpeldUdClc
MQTT: https://www.youtube.com/watch?v=EH3GQzKvdZw

Arduino / C Programming:

**Purpose**
In this project, students can apply their theoretical knowledge acquired in their previous studies. With this and some new theory they realize a sub-project of a smart home project. They work together in small groups of American and German students. The solution is a functional device and/or software.
Objectives - learning outcomes

After that project part students should be able to:

- work in international groups of different cultures.
- do literature research on a previously unknown subject.
- communicate over a long distance via multimedia.
- apply their previous knowledge and new features to a practical result.
- realize a project with concept phase, executing phase and presentation.
- do first project management.
- have first experience in programming smart phones and single board computers.
- write a project documentation.
- present their results in front of an audience

Course Schedule

Look at separate schedule of the project!
Assessment Instruments
- project meeting 2 times a week
- vocal presentation of project status
- documentation
- final functional presentation at TTU.

Grading Policy
Final grade is determined based on vocal presentation of project status and the final functional presentation. Letter grades will be assigned using University standards. The approximate weighting of graded material in determining the final grade is as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Percent of Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>vocal presentation</td>
<td>30 %</td>
</tr>
<tr>
<td>documentation</td>
<td>30 %</td>
</tr>
<tr>
<td>final presentation</td>
<td>40 %</td>
</tr>
</tbody>
</table>

Grades will be provided latest 2 weeks after the end of the project.

Academic Misconduct
Cheating, plagiarism and academic dishonesty will not be tolerated.

Disability Policy
“Any student who, because of a disability, may require special arrangements in order to meet the course requirements should contact the instructor as soon as possible to make any necessary arrangements. Students should present appropriate verification from Student Disability Services during the instructors office hours. Please note instructors are not allowed to provide classroom accommodations to a student until appropriate verification from Student Disability Services has been provided. For additional information, you may contact the Student Disability Services office at TTU 335 West Hall or 806- 742-2405.