Martin H. Trauth

MATLAB/Lego Mindstorms Practical

Remote Sensing, geoInformation and Visualization (RSIV)

1st Year	Winter	**Mandatory Module 1:** RCM01 Remote Sensing of the Environment (6)	**Mandatory Module 2:** RCM02 Earth System Sciences (6)	**Mandatory Module 3:** RCM03 Data Analysis and Statistics (6)	**Mandatory Module 4:** RCM04 Geoinformation Systems (6)	**Mandatory Module 5:** RCM05 Visualization and Communication (6)
	Summer	**Elective Module 1:** Remote Sensing Methods (6)	**Elective Module 2:** Objects of Observation (6)	**Elective Module 3:** Data Analysis and Programming (6)	**Elective Module 4:** Geoinformation System Applications (6)	**Elective Module 5:** Visualization and Communication (6)
2nd Year	Winter	**Elective Module:** Wahlpflichtmodul (6)	**Elective Module:** Wahlpflichtmodul (6)	**Elective Module:** Wahlpflichtmodul (6)	**Elective Module:** Wahlpflichtmodul (6)	**Elective Module:** Wahlpflichtmodul (6)
	Summer	Masterarbeit (6)				

Remote Sensing Methods
- RSM01 Optical Remote Sensing
- RSM02 Terrestrial and Airborne Lidar and Photogrammetry Systems
- RSM03 Remote Chemical Sensing
- RSM04 Earth Surface Deformation and Radar Satellite Interferometry
- RSM05 Advanced Topics of Remote Sensing Methods

Objects of Observation
- OBS01 Soilscape Processes
- OBS02 Sediment-mass transport on the Earth's Surface
- OBS03 Biospheres of the Earth
- OBS04 Remote Sensing und Permafrost
- OBS05 Earthquake and Volcano deformation
- OBS06 Earth Magnetic Field and Physics of the Upper Atmosphere
- OBS07 Climate Change and Climate Dynamics
- OBS08 Planetary Remote Sensing
- OBS09 Planetary Physics
- OBS10 Atmospheric Science in the Anthropocene
- OBS11 Advanced Topics of Objects of Observations

Data Analysis and Programming
- DAP01 Bayesian inference and data assimilation
- DAP02 Nonlinear Data Analysis Concepts
- DAP03 Big Data Analytics
- DAP04 Spatial data analysis with numerical methods
- DAP05 Advanced Data Analysis and Programming

Geoinformation System Applications
- GIS01 Analysis of Digital Elevation Models
- GIS02 Mapping and Geoinformation Systems
- GIS03 Environmental Spatial Statistics and Models
- GIS04 GIS, Geoharzards, Georisks
- GIS05 Advanced Geoinformation System Applications

Visualization and Communication
- VCM01 Examples of Visualization and Communication Methods
- VCM02 Industry Internship or Practical Application
- VCM03 Extended Internship or Practical Application
- VCM04 Advanced Visualization and Communication Methods

<table>
<tr><th colspan="3">GEW-RCM03: Data Analysis and Statistics</th><th colspan="2">Number of credit points (CPs): 6</th></tr>
<tr><td>Module type (mandatory or elective):</td><td colspan="4">Mandatory module</td></tr>
<tr><td>Content and Objectives of Module</td><td colspan="4">Content
Introduction to a higher-level programming language such as Python or MATLAB; overview of data types and methods; one-, two-, and multi-variable statistics; time series analysis; statistics for spatial and directional data; numerical procedures; image processing and analysis.

Objective
The students are capable of self-reliantly planning, executing, and presenting a data analysis project.</td></tr>
<tr><td>Module (partial) examination (number, form, scope):</td><td colspan="4">Portfolio exam (presentation of the results of the digital data analysis project, 10–15 minutes, with accompanying report, 10–12 pages)</td></tr>
<tr><td>Independent study time (in hours):</td><td colspan="4">120</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td rowspan="2">Courses (type of teaching)</td><td rowspan="2">Contact time: (in semester hours)</td><td colspan="2">Supplementary exam work (number, form, scope)</td><td rowspan="2">(Partial) module exams accompanying coursework (number, form, scope)</td></tr>
<tr><td>For completing the module</td><td>For admission to the module exam</td></tr>
<tr><td>Lecture and tutorial</td><td>3</td><td>-</td><td>Practice assignments (80%)</td><td>-</td></tr>
<tr><td>Seminar</td><td>1</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="2">Offered:</td><td colspan="3">Winter semester</td></tr>
<tr><td colspan="2">Prerequisite for taking the module:</td><td colspan="3">None</td></tr>
<tr><td colspan="2">Teaching unit:</td><td colspan="3">Earth sciences</td></tr>
</table>

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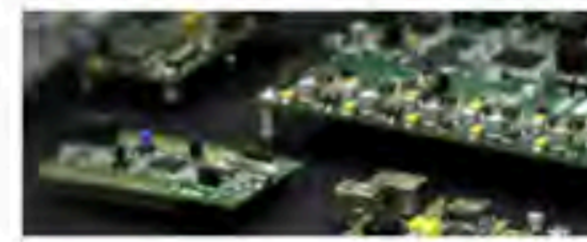

Run Simulink models directly on Arduino, Raspberry Pi, and LEGO MINDSTORMS robots

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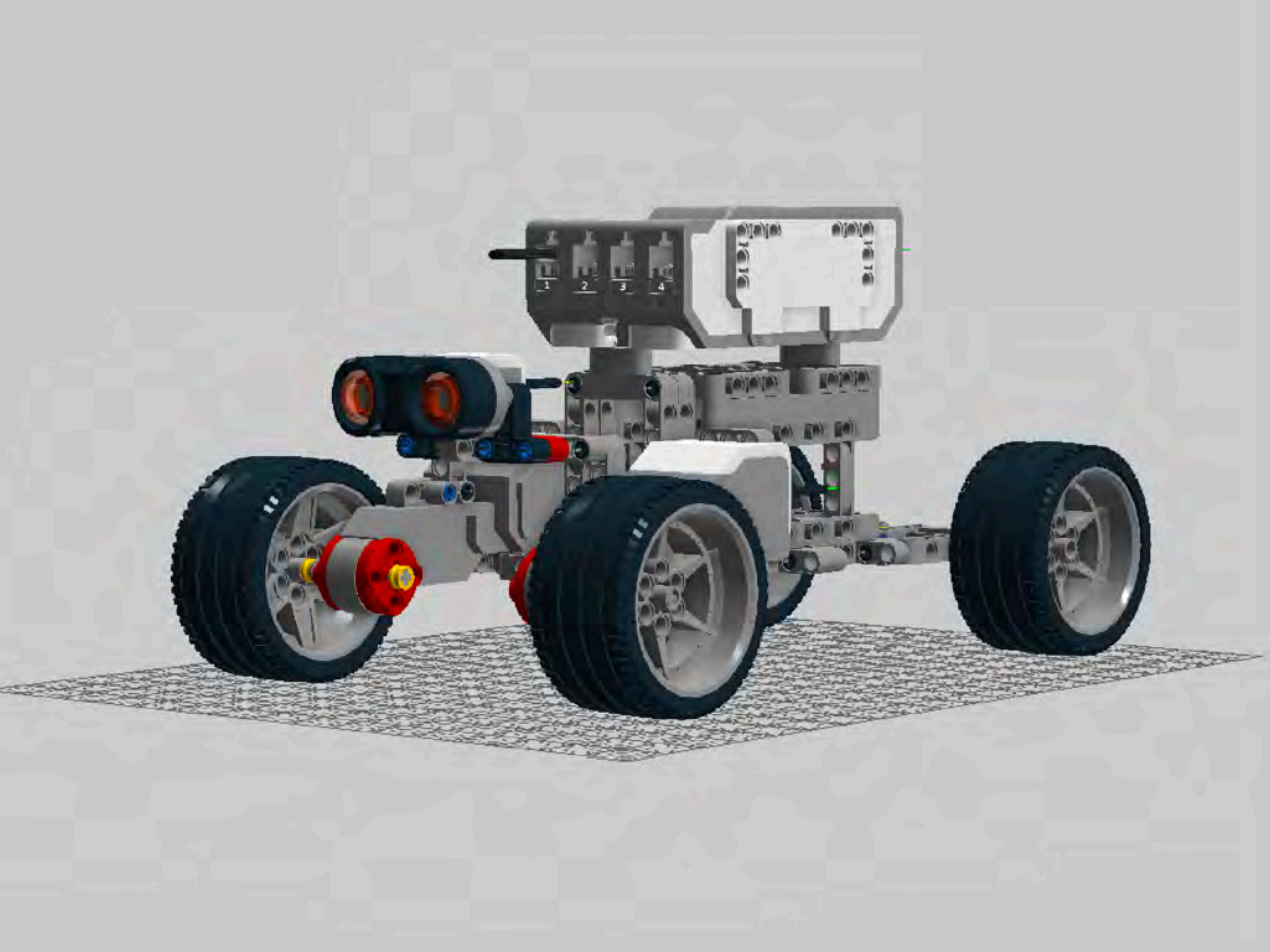
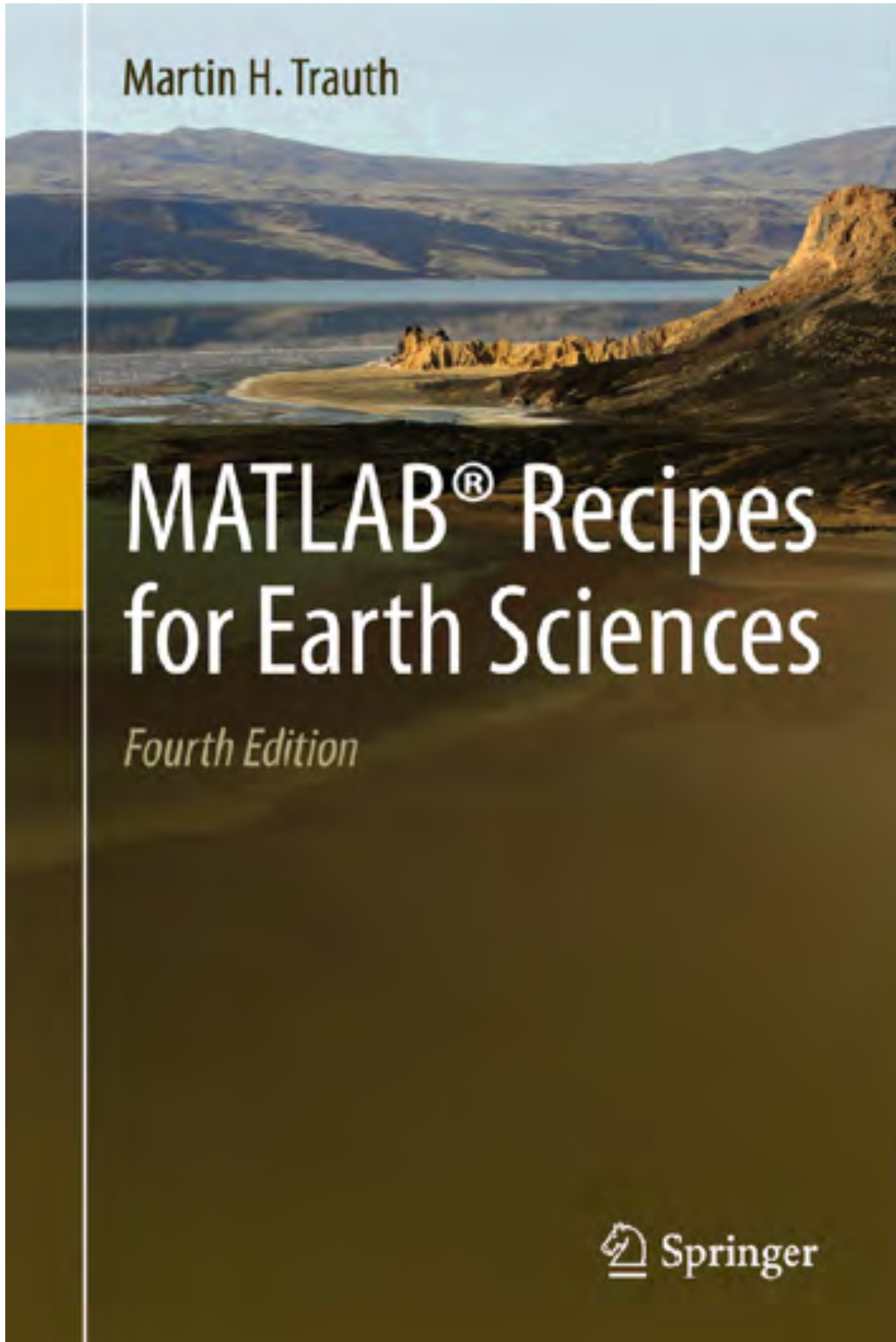
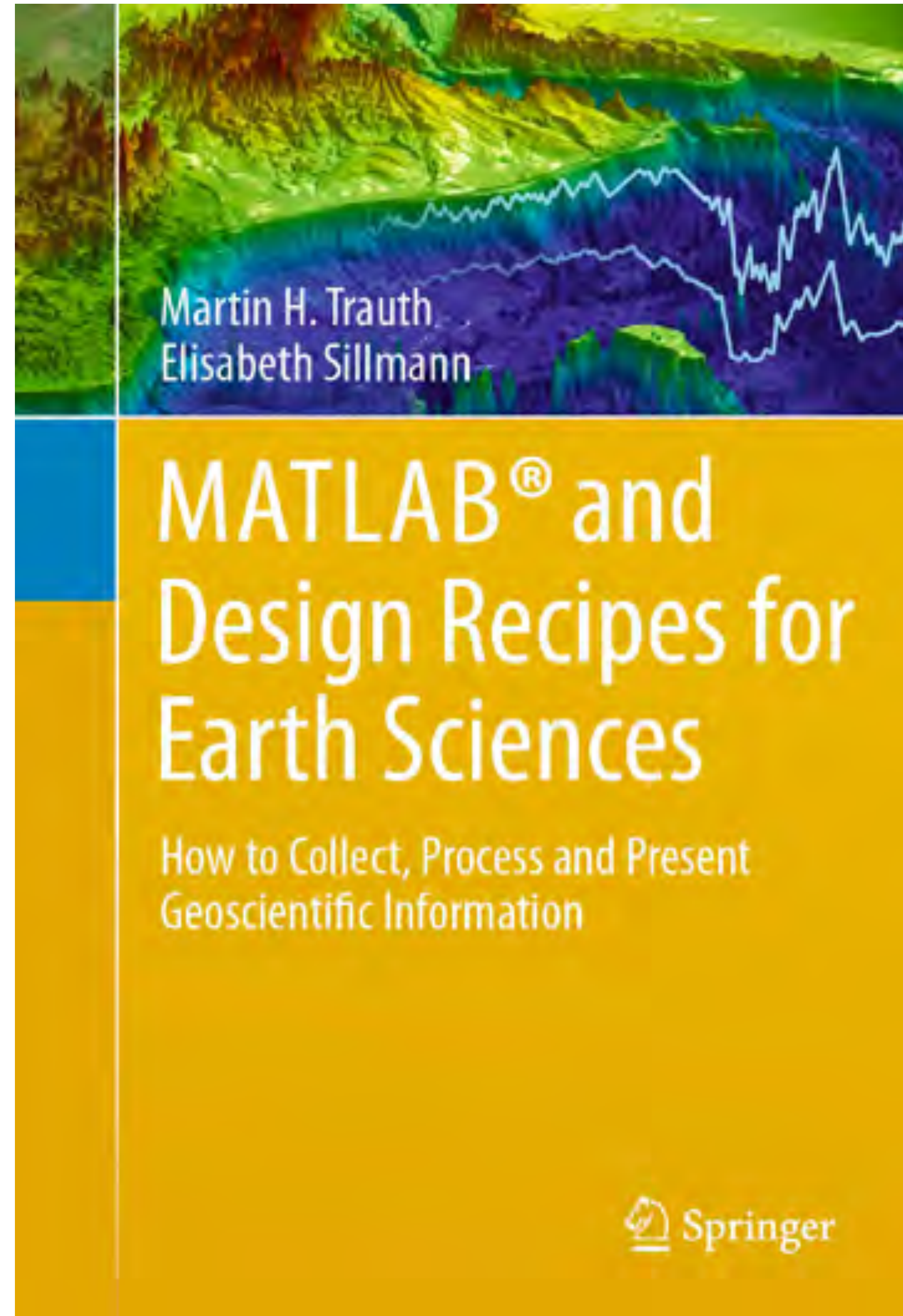
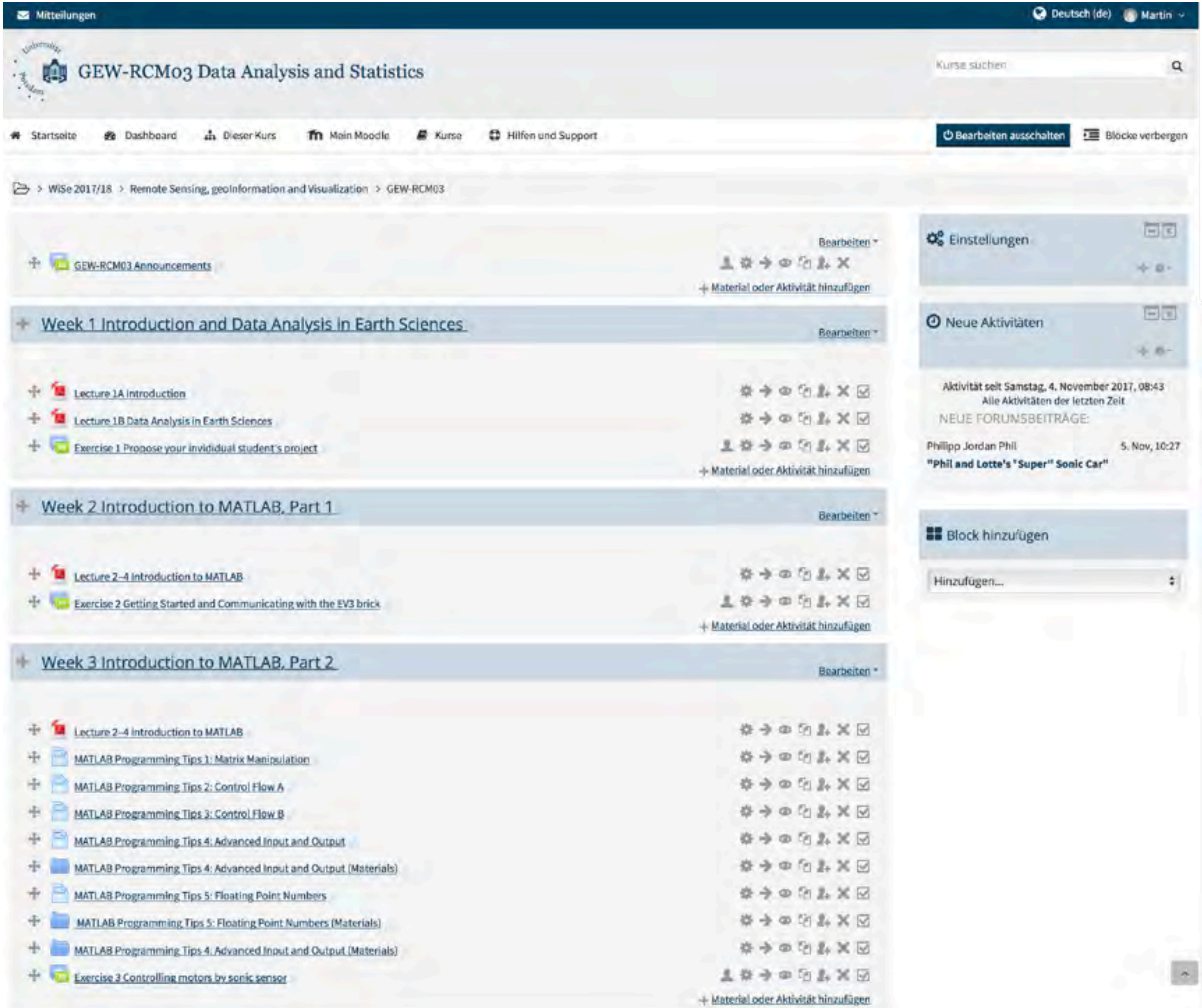

1
2
3
4

	Topic	Lectures	Labs
20. October 2017	Introduction, Data Analysis in Earth Sciences	MRES Chapter 1	Intro to labs, MATLAB resources, setting up computers (1.10)
27. October 2017	Introduction to MATLAB, Part 1	MRES Chapter 2	Communicating with EV3 brick (1.10)
03. November 2017	Introduction to MATLAB, Part 2	MRES Chapter 2	Control flow and controlling EV3 motors by sonic sensor (1.10)
10. November 2017	Introduction to MATLAB, Part 3	MRES Chapter 2	MATLAB mobile, smartphone GPS tracking (Golm Campus)
17. November 2017	Univariate Statistics	MRES Chapter 3	Precision and accuracy of US and IR sensors (1.10)
24. November 2017	Bivariate Statistics	MRES Chapter 4	Spatial resolution of sonic and IR sensors (1.10)
01. Dezember 2017	Time-Series Analysis, Part 1	MRES Chapter 5	Mapping temperature of water, determine cooling trend (1.10)
08. Dezember 2017	Time-Series Analysis, Part 2	MRES Chapter 5	Climate trends, rhythms and events (1.10)
15. Dezember 2017	Signal Processing	MRES Chapter 6	Designing filters to extract cycles from time series (1.10)
22. Dezember 2017	(Christmas holidays)		
29. Dezember 2017	(Christmas holidays)		
05. Januar 2018	Spatial Data	MRES Chapter 7	Generating point clouds from stereo images (1.10)
12. Januar 2018	(No course)	(No course)	(No course)
19. Januar 2018	Image Processing, Part 1	MRES Chapter 8	Rectification and referencing RGB images (1.10)
26. Januar 2018	Image Processing, Part 2	MRES Chapter 8	Stitching multiple RGB images (1.10)
02. Februar 2018	Multivariate Statistics	MRES Chapter 9	Multispectral imaging including NDVI (Botanic Garden)
09. Februar 2017	Directional Data	MRES Chapter 10	Smartphone magnetic scanner (1.10)
16. Februar 2018	Examination, Option 1		
06. April 2018	Examination, Option 2		


Martin H. Trauth
MATLAB® Recipes
for Earth Sciences
Fourth Edition
Springer


Martin H. Trauth
Elisabeth Sillmann
MATLAB® and
Design Recipes for
Earth Sciences
How to Collect, Process and Present
Geoscientific Information
Springer


Mitteilungen
Deutsch (de)
Martin
GEW-RCM03 Data Analysis and Statistics
Kurse suchen
Startseite
Dashboard
Dieser Kurs
Mein Moodle
Kurse
Hilfen und Support
Bearbeiten ausschalten
Blöcke verbergen
WiSe 2017/18 > Remote Sensing, geoInformation and Visualization > GEW-RCM03
Bearbeiten
GEW-RCM03 Announcements
Material oder Aktivität hinzufügen
Week 1 Introduction and Data Analysis in Earth Sciences
Bearbeiten
Lecture 1A Introduction
Lecture 1B Data Analysis in Earth Sciences
Exercise 1 Propose your invididual student's project
Material oder Aktivität hinzufügen
Week 2 Introduction to MATLAB, Part 1
Bearbeiten
Lecture 2–4 Introduction to MATLAB
Exercise 2 Getting Started and Communicating with the EV3 brick
Material oder Aktivität hinzufügen
Week 3 Introduction to MATLAB, Part 2
Bearbeiten
Lecture 2–4 Introduction to MATLAB
MATLAB Programming Tips 1: Matrix Manipulation
MATLAB Programming Tips 2: Control Flow A
MATLAB Programming Tips 3: Control Flow B
MATLAB Programming Tips 4: Advanced Input and Output
MATLAB Programming Tips 4: Advanced Input and Output (Materials)
MATLAB Programming Tips 5: Floating Point Numbers
MATLAB Programming Tips 5: Floating Point Numbers (Materials)
MATLAB Programming Tips 4: Advanced Input and Output (Materials)
Exercise 3 Controlling motors by sonic sensor
Material oder Aktivität hinzufügen
Einstellungen
Neue Aktivitäten
Aktivität seit Samstag, 4. November 2017, 08:43
Alle Aktivitäten der letzten Zeit
NEUE FORUMSBEITRÄGE:
Philipp Jordan Phil
5. Nov, 10:27
"Phil and Lotte's "Super" Sonic Car"
Block hinzufügen
Hinzufügen...

MATLAB RECIPES FOR EARTH SCIENCES

Martin H. Trauth, University of Potsdam, Germany

CATEGORY: LEGO MINDSTORMS

SEPTEMBER 19, 2017

U Potsdam Article About the MATLAB/LEGO MINDSTORMS Practical

Today the University of Potsdam published an article (in German) by Matthias Zimmermann about the MATLAB/LEGO MINDSTORMS practical, sponsored by MathWorks Inc. The practical, part of the master's courses "Geosciences" and "Remote Sensing, geoInformation and Visualization", as well as of the Summer School on Earth Surface Dynamics, aims to improve student's skills to build efficient teams to solve typical problems in earth sciences in acquiring, processing and analyzing typical multispectral (visible, infrared, thermal), geophysical (seismic, magnetic) and geometric (2D, 3D) data. Photo: Karla Fritze.

SOCIAL MEDIA

Follow @MartinHTrauth

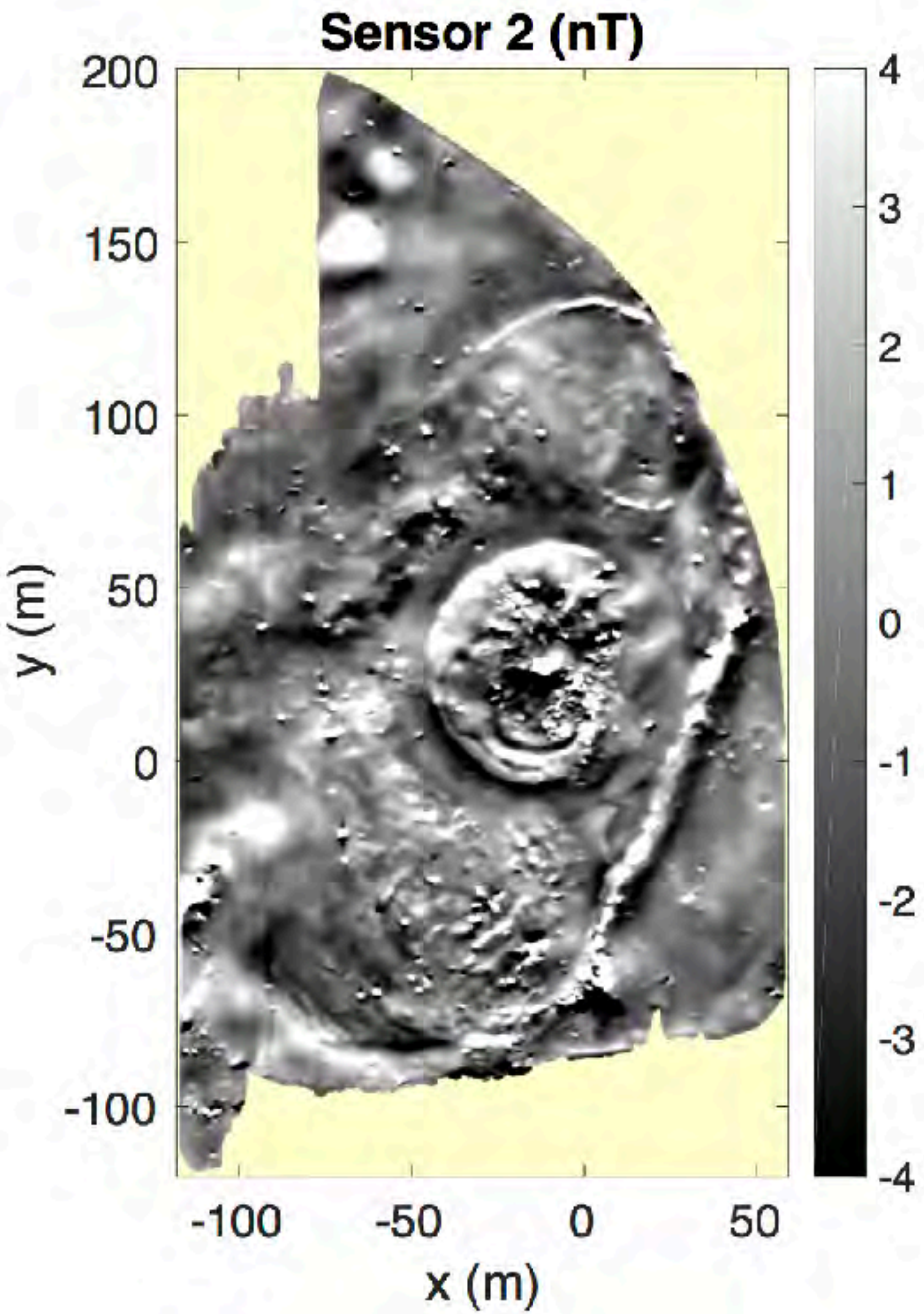
THE BOOKS

Trauth, M.H. (2015) MATLAB Recipes for Earth Sciences – Fourth Edition. Springer, 427 p., Supplementary Electronic Material, Hardcover, ISBN: 978-3-662-46244-7. (MRES)

Trauth, M.H., Sillmann, E. (2012) MATLAB and Design Recipes for Earth Sciences: How to collect, process and present geoscientific information. Springer, 292 p., Supplementary Electronic Material, Hardcover, ISBN: 978-3-642-32543-4. (MDRES)

ABOUT ME

I am a geoscientist, apl. professor of paleoclimate dynamics at the University of Potsdam. I have been using MATLAB since late 1992, especially for the analysis of paleoclimatic series. Please visit my university webpage http://martinhtrauth.de

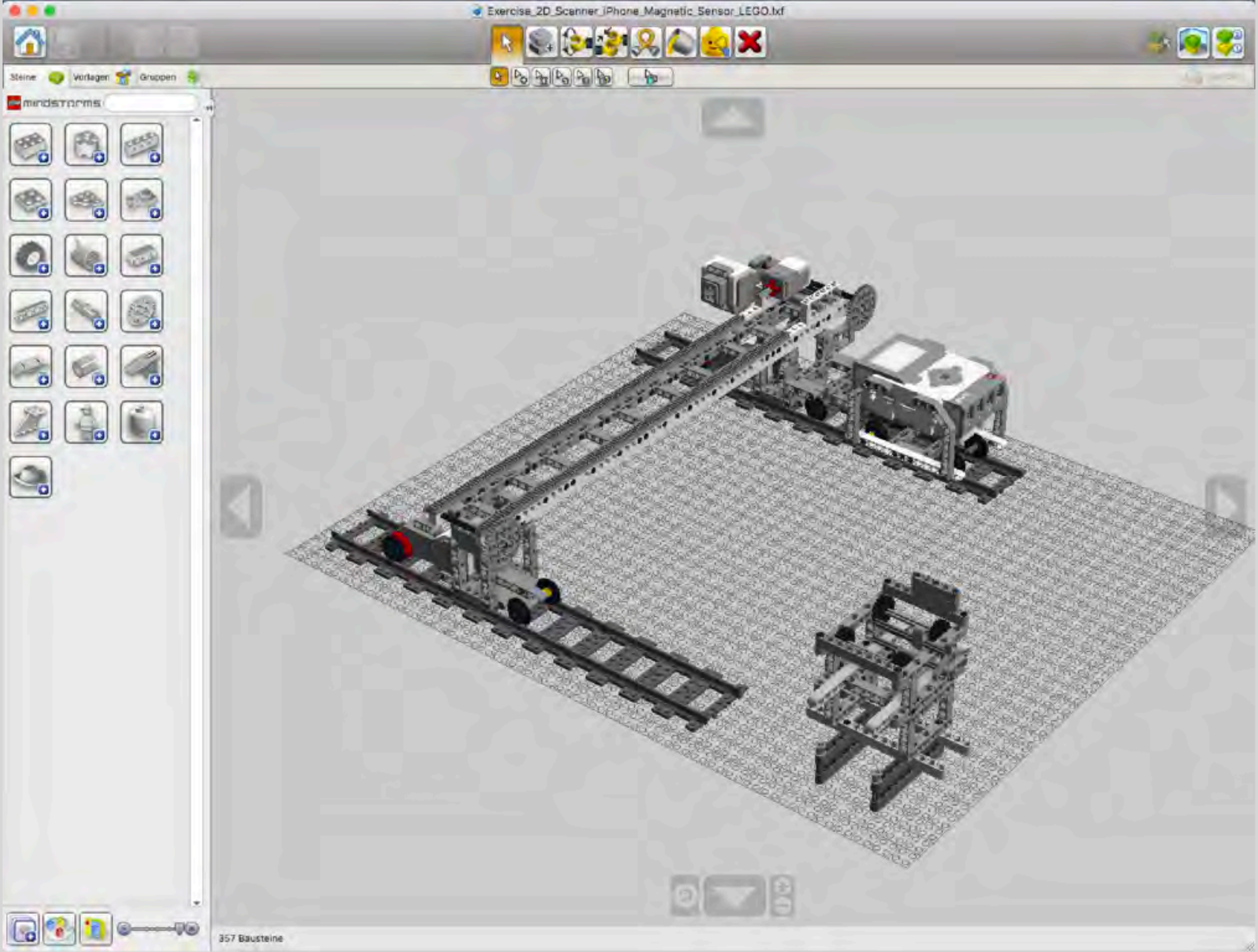

Sensor 2 (nT)
200
150
100
50
0
-50
-100
y (m)
-100
-50
0
50
x (m)
4
3
2
1
0
-1
-2
-3
-4

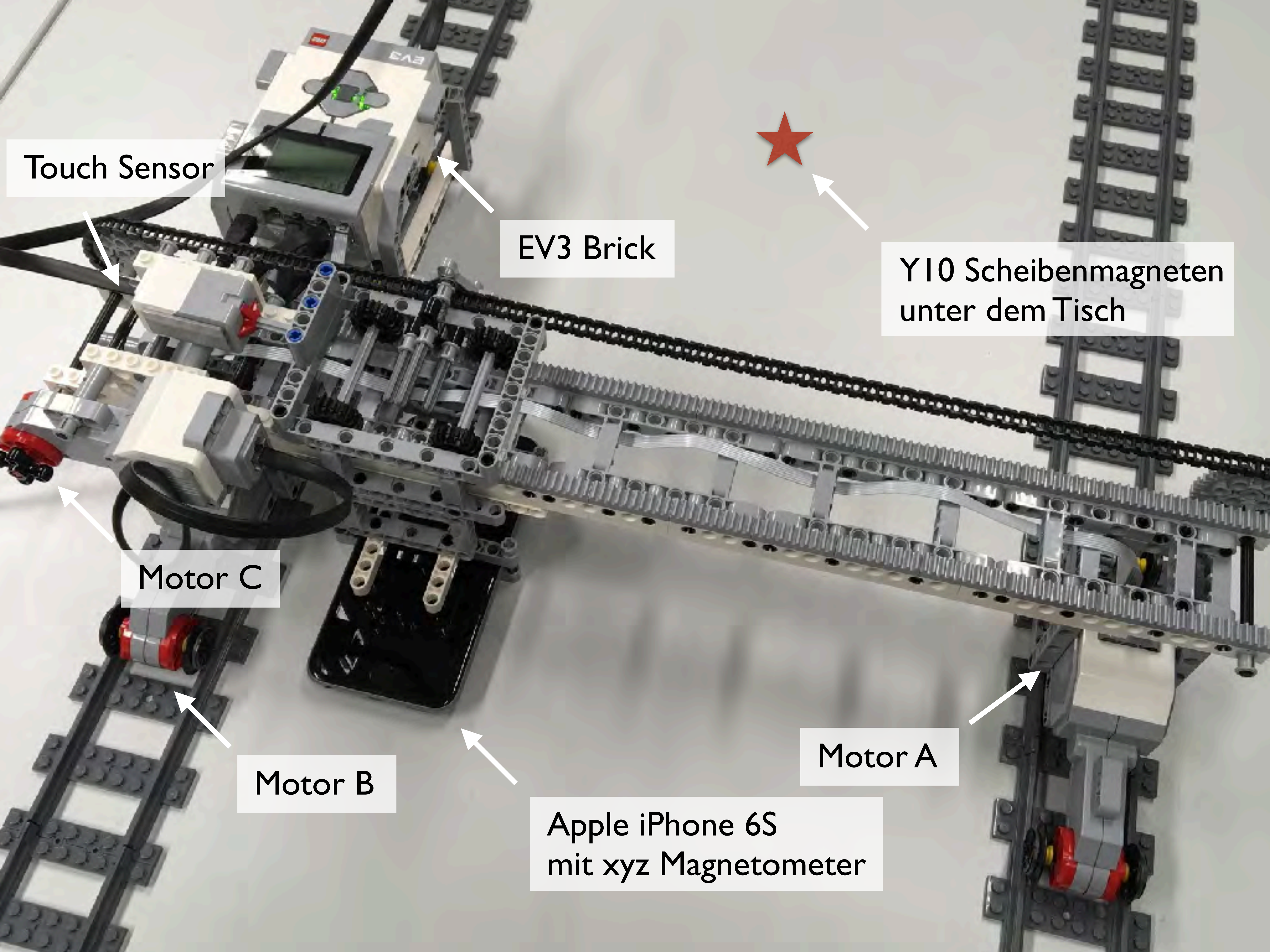
Exercise „Generating a point cloud from stereo images“

1. Build a four-wheeled LEGO vehicle on rails with a single large motor with a RGB camera mounted on the vehicle facing to the side.
2. Acquire 2D stereo images of a three-dimensional object of your choice with the RGB camera moved by the vehicle along an object of interest.
3. Process and analyze the stereo images to calculate the 3D geometry of the object.
4. Visualize a 3D point cloud from the stereo images.

Solution „Generating a point cloud from stereo images"

1. First you have to build the vehicle according to the LEGO building instructions. The building instructions are in a LXF file which can be opened with the free LEGO Digital Designer software, which is available for Computers running macOS or Windows. After launching the software you can use the view menu to switch from the construction mode to the building instructions mode.
5. You need the Computer Vision Toolbox and a high-resolution RGB camera, which is supported by MATLAB, such as the Logitech C922 Pro Stream Webcam. To access the camera using MATLAB you need the appropriate hardware support package for your camera. Install the hardware support on your computer and read the documentation.
6. In order to create the point cloud of the object, you first have to calibrate the camera. For this, you need a printout of the checkerboard pattern of which you have to take 3 to 20 pictures from different angles with the camera you want to calibrate. The checkerboard pattern can be obtained by typing "open checkerboardPattern.pdf" in the Command Window of MATLAB. The distance between the camera and the checkerboard should be about the same as to the object you want to record later. The calibration can be done with the Single Camera Calibration App. After you calibrated your camera following the instructions, you have to create a camera calibration file, which contains the intrinsic, extrinsic, lens distortion, and estimation properties for your camera.
2. To generate the point cloud, you have to take two pictures from different positions with an overlap of approximately 60% or more. For the best results, you should use an object with clear structures and high contrasts. For this you need to take a picture, move the vehicle for short amount of time and take another picture. Your MATLAB script creates connections to the motor and the camera, moves the vehicle and acquire the images.
7. Load the image files into MATLAB and apply the camera calibration file to remove image distortions.
8. In order to determine the difference between the two images you have to define pairs of points clearly visible in both images. One method to fine these reference points is the detectMinEigenFeatures algorithm. To determine the transformation vector of each individual reference point between the two images you can use a point tracker.
9. In order to located each individual reference point in the 3D space you have to find corresponding points in the two stereo images. This can be done with the essential matrix. Furthermore, you need to calculate the camera position and the camera projection matrix to project the images.
10. With the function triangulate and the calculated and matched points you can calculate the location of all points in the 3D space and hence the 3D point cloud of the object.
11. The point cloud can be visualized with pcshow.


Exercise_2D_Scanner_iPhone_Magnetic_Sensor_LEGO.lxf
Steine
Vorlagen
Gruppen
mindstorms
357 Bausteine

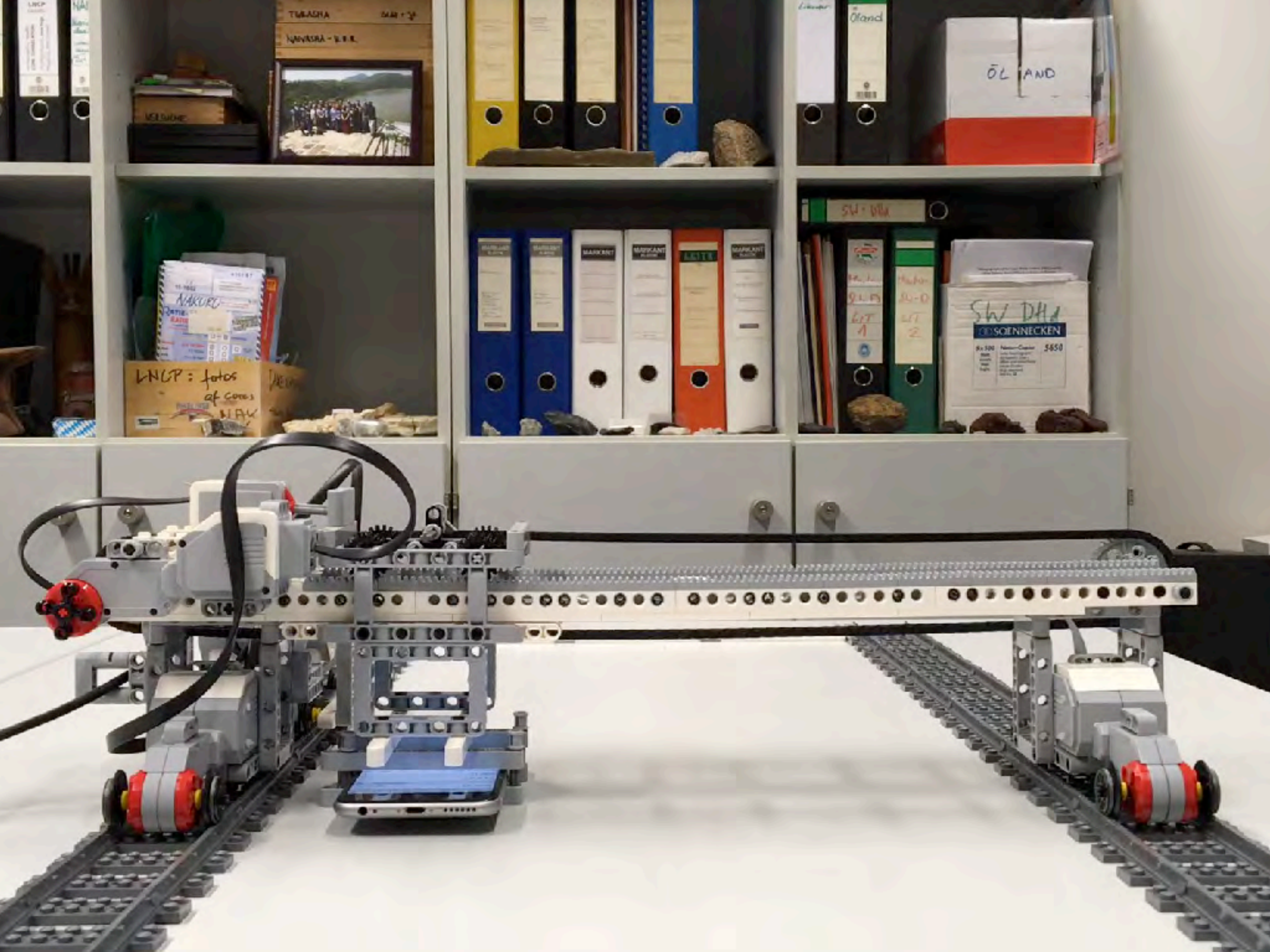

Touch Sensor
EV3 Brick
Y10 Scheibenmagneten
unter dem Tisch
Motor C
Motor B
Motor A
Apple iPhone 6S
mit xyz Magnetometer


chipworks

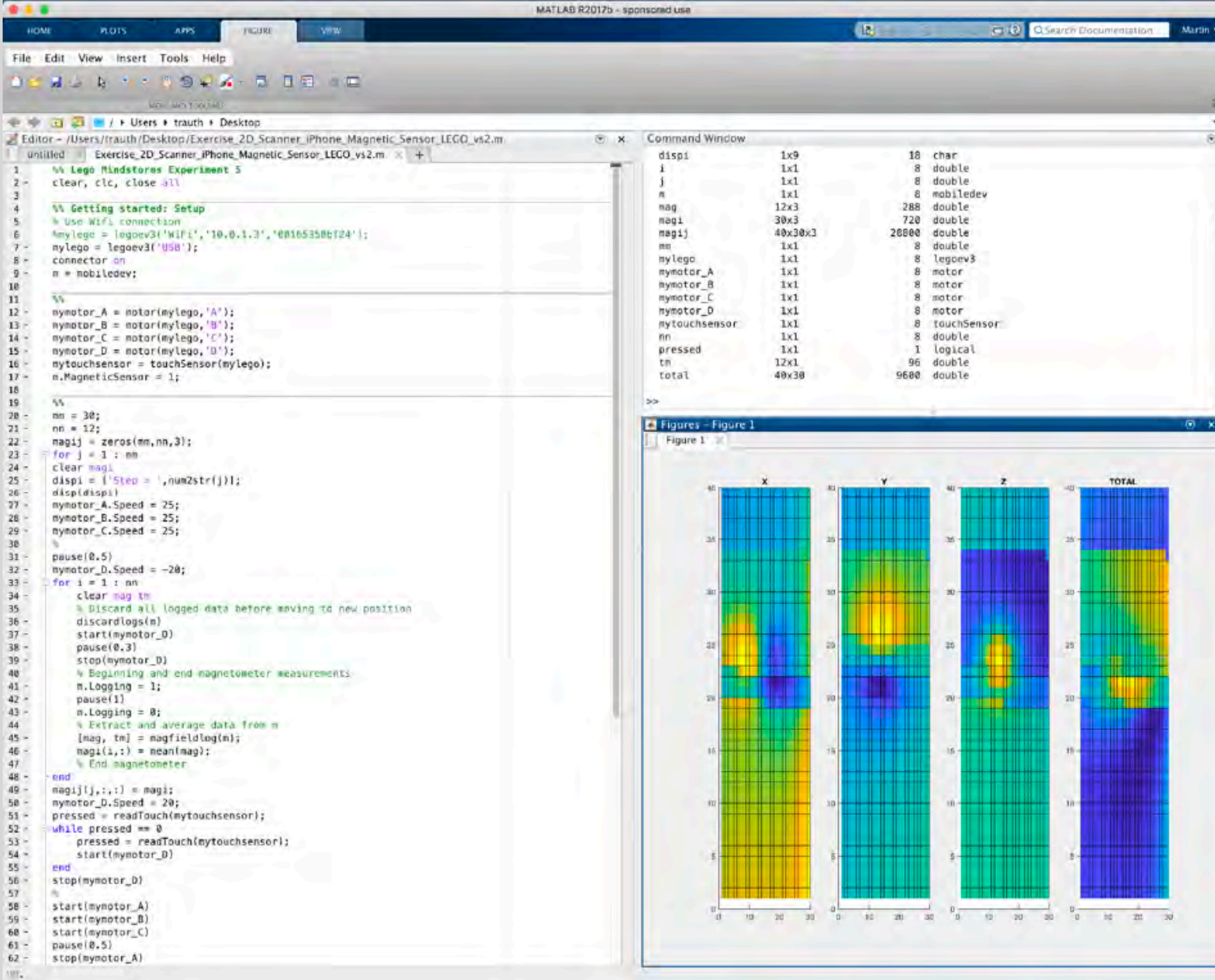
General Magnetic Material Grade Scale Chart

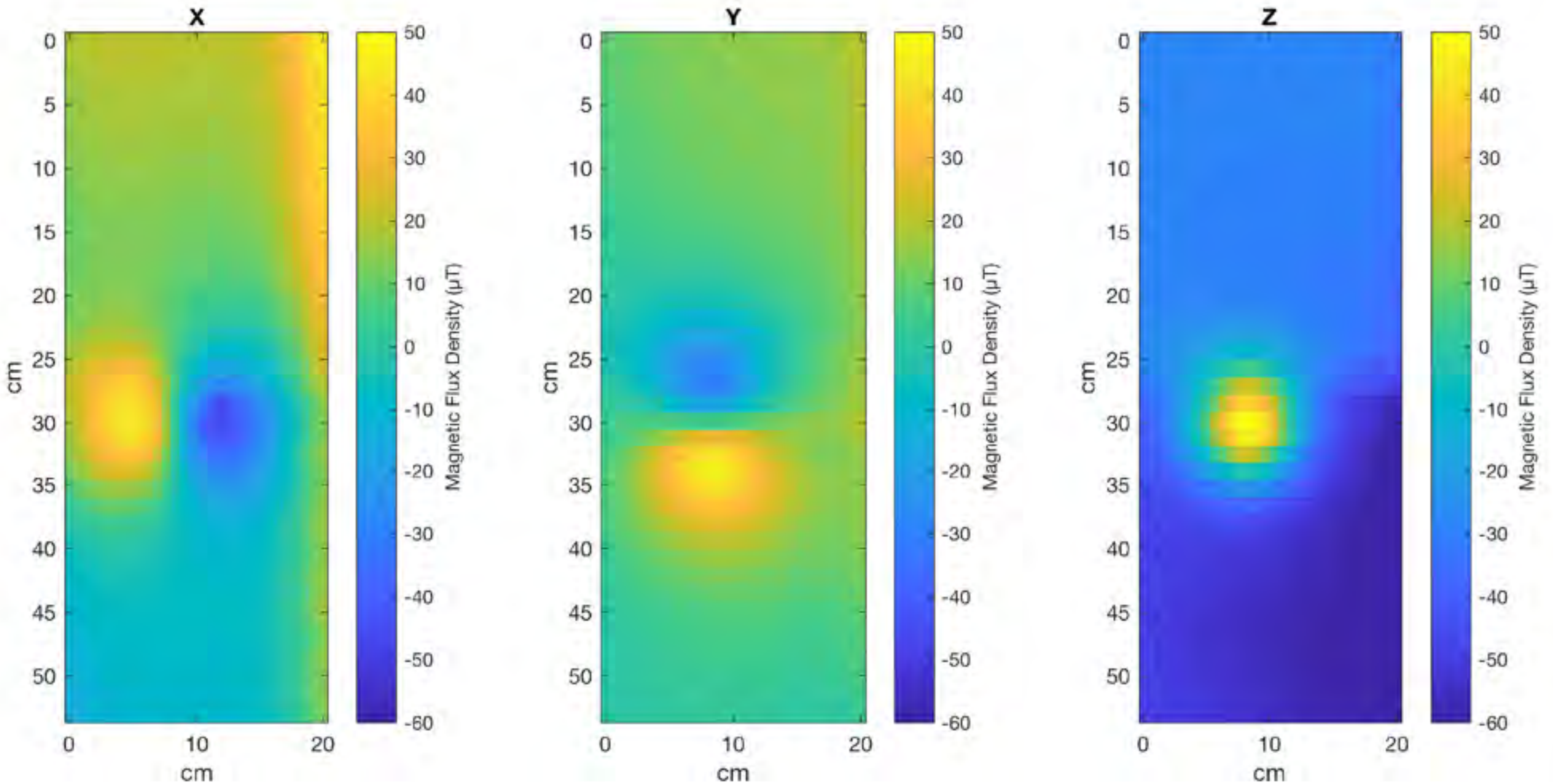
[Magnetic Products List]

Magnetic Material	Grade		Magnetic force	BHmax Scale	Work Temperature (^{0}C)	Use Area
Ferrite Magnet Ceramic Magnet	C1, Y10	Isotropic	Low	10	$<300^{0}C$	Magnetic beads, Toy motor, Refrigerator door badge, *magnetic toy, magnets for education* tool
	C5,Y30	Anisotropic	Middle, higher than C1, Y10	28	$<300^{0}C$	Earphone, Speaker, DC motors, Magnetic separators, Loud speaker, Generator, Magnetic tool, MRI, Magnetic ball, Super Magnetic beads
	C8,Y30BH	Anisotropic	Middle, equal or a little higher than C5, Y30	30	$<300^{0}C$	
Sintered NdFeB Magnet Rare earth Magnet	N33	Anisotropic	High, strong magnet,	300	$<80^{0}C$	Earphone, Smartphone, Speaker, Magnetic tool, Magnetic Appliance, Magnetic Assembly, Magnetic Fasten, MRI, Magnetic clasp, Stringless bracelet
	N35	Anisotropic	High, strong magnet,	330	$<80^{0}C$	
	N38	Anisotropic	High, strong magnet,	350	$<80^{0}C$	
	N40		High, strong magnet,	380	$<80^{0}C$	
	N38SH	Anisotropic	High, strong magnet, equal or little high than N35, but it is good to work at a little high temperatue	360	$<150^{0}C$	HDD, CD-ROM, Computer, DC motor, Airplane, Aircraft, Military Weapon, Magnetic clasp
		Anisotropic	High, very strong magnet,	420	$<80^{0}C$	
		Isotropic	Middle, more higher than C8,Y30BH Ferrite magnet	60	$<120^{0}C$	HDD, CD-ROM, DC motor, Precise Motor
		Isotropic	Low	10	$<80^{0}C$	Refrigerator door, Decoration, Magnetic paper, Advertisement
		Anisotropic	Low, equal or high C1, Y10	15	$<80^{0}C$	DC motor



Öland
ÖLAND
SW DHd
SOENNECKEN
LEITZ
MARKANT


MATLAB R2017b - sponsored use
HOME
PLOTS
APPS
FIGURE
VIEW
Search Documentation
Martin
File Edit View Insert Tools Help
/ ▸ Users ▸ trauth ▸ Desktop
Editor - /Users/trauth/Desktop/Exercise_2D_Scanner_iPhone_Magnetic_Sensor_LEGO_vs2.m
untitled
Exercise_2D_Scanner_iPhone_Magnetic_Sensor_LEGO_vs2.m
%% Lego Mindstorms Experiment 5
clear, clc, close all
%% Getting started: Setup
% Use Wifi connection
%mylego = legoev3('WiFi','10.0.1.3','00165358f24');
mylego = legoev3('USB');
connector on
m = mobiledev;
%%
mymotor_A = motor(mylego,'A');
mymotor_B = motor(mylego,'B');
mymotor_C = motor(mylego,'C');
mymotor_D = motor(mylego,'D');
mytouchsensor = touchSensor(mylego);
m.MagneticSensor = 1;
%%
mm = 30;
nn = 12;
magij = zeros(mm,nn,3);
for j = 1 : mm
clear magi
dispi = ['Step = ',num2str(j)];
disp(dispi)
mymotor_A.Speed = 25;
mymotor_B.Speed = 25;
mymotor_C.Speed = 25;
%
pause(0.5)
mymotor_D.Speed = -20;
for i = 1 : nn
clear mag tm
% Discard all logged data before moving to new position
discardlogs(m)
start(mymotor_D)
pause(0.3)
stop(mymotor_D)
% Beginning and end magnetometer measurements
m.Logging = 1;
pause(1)
m.Logging = 0;
% Extract and average data from m
[mag, tm] = magfieldlog(m);
magi(i,:) = mean(mag);
% End magnetometer
end
magij(j,:,:) = magi;
mymotor_D.Speed = 20;
pressed = readTouch(mytouchsensor);
while pressed == 0
pressed = readTouch(mytouchsensor);
start(mymotor_D)
end
stop(mymotor_D)
%
start(mymotor_A)
start(mymotor_B)
start(mymotor_C)
pause(0.5)
stop(mymotor_A)
Command Window
dispi 1x9 18 char
i 1x1 8 double
j 1x1 8 double
m 1x1 8 mobiledev
mag 12x3 288 double
magi 30x3 720 double
magij 40x30x3 28800 double
mm 1x1 8 double
mylego 1x1 8 legoev3
mymotor_A 1x1 8 motor
mymotor_B 1x1 8 motor
mymotor_C 1x1 8 motor
mymotor_D 1x1 8 motor
mytouchsensor 1x1 8 touchSensor
nn 1x1 8 double
pressed 1x1 1 logical
tm 12x1 96 double
total 40x30 9600 double
>>
Figures - Figure 1
Figure 1
X
Y
Z
TOTAL



X
Y
Z
cm
Magnetic Flux Density (μT)

Spielerisch lernen: Im Datenanalysekurs von Martin Trauth kein Problem.

„Mit Lego kannst du mehr"

Wie kommen Plastikbausteine in ein Uni-Praktikum?

Das Praktikum von Martin Trauth ist vollgestopft mit Hightech: Infrarot- und Ultraschall-Sensoren, Gyroskopen, Magnetometern, Multispektralkameras – und Lego-Steinen. Gemeinsam mit den Studierenden entwickelt, baut und programmiert Trauth damit geowissenschaftliche Messanordnungen im Maßstab eines Labortisches nach, die eigentlich im Gelände eingesetzt werden. Der Erfolg gibt ihm recht: Der Kurs ist voll, alle sind begeistert. Auch Martin Trauth – von den Möglichkeiten und nicht zuletzt von den Studierenden.

Von Matthias Zimmermann

Angefangen hat alles mit einem Kurs zur Analyse von Daten in den Geowissenschaften, den der Professor für Paläoklimadynamik jedes Jahr durchführt. „Ich dachte mir, anstatt den Leuten immer fertig gemessene Daten vorzusetzen, wäre es besser, sie selbst messen zu lassen. Und zwar am besten direkt auf dem Tisch im Seminarraum", sagt Trauth. Das Problem: Die dafür nötigen Messinstrumente sind – im Originalformat – teuer und für den Einsatz in einem Praktikum zu unhandlich. Anders Lego, das mitnichten nur in Kinderzimmern zu Hause ist. Mit Lego Mindstorms hat der Bausteinriese aus Dänemark eine ganze Produktreihe entwickelt, die mit Pneumatikteilen, Zahnrädern, Elektromotoren, Sensoren und sogar einem programmierbaren Herzstück namens Lego Mindstorms EV3 Brick aufwarten kann und längst auch als Lehrmittel eingesetzt wird. Als Trauth, der schon seit den frühen 1990er-Jahren mit der in den Geowissenschaften verbreiteten Programmiersprache MATLAB arbeitet und sogar eines der erfolgreichsten Lehrbücher dafür geschrieben hat, erfuhr, dass es eine Schnittstelle zwischen MATLAB und Lego Mindstorms gibt, war der Schritt nicht mehr weit.

Dank der Firma MathWorks, die hinter MATLAB steckt und die Idee von Martin Trauth unterstützte, standen bald Kisten mit Lego-Steinen und unterschiedlichen Sensoren im Wert von 6.000 Euro auf dessen Schreibtisch – und kurz darauf vor den Studierenden. Seitdem wird im Kurs für Datenanalyse gebaut, programmiert und gemessen. „Die Studierenden haben viel Spaß beim Praktikum", sagt Trauth nicht ohne Stolz, „weil hier jedes Mal was Schräges ausprobiert wird." Zum Auftakt sollen die Teilnehmer ein Auto konstruieren, das geradeaus fährt, 30 Zentimeter vor einem Hindernis anhält, piept und zurückfährt. Wie, dafür sollen sie selbst Ideen entwickeln. Trauth und sein Team helfen, wenn nötig. „Sie machen dabei, was wir in der Wissenschaft ständig tun: anwenden, was wir kennen, um Neues zu entwickeln. Und wenn etwas schief geht, neu anfangen."

Auf einfache Aufgaben folgen komplexere: etwa mithilfe eines Ultraschallsensors dreidimensionale Objekte vermessen. „Das Tolle: Je komplizierter die Übungen werden, desto weniger Hilfe brauchen sie", sagt der Geowissenschaftler. Der 90-minütige Kurs dauere auch schon mal drei Stunden. Früher gehen wolle trotzdem niemand, meint der Forscher. „Die Leute sind begeistert bei der Sache, vor allem auch wegen des Einsatzes von Lego. Jeder kennt und liebt Lego. Der Spieltrieb ist geweckt, es wird viel gelacht während des Kurses."

Trauth ist selbst im Lego-Fieber, nicht erst seitdem er mit seinem vierjährigen Sohn wieder Lego-Autos baut. Zugleich verliert er das Ziel des Praktikums nie aus den Augen: „Mit dem Spielerischen habe ich die Leute zum Programmieren gebracht. Sie bauen ihre Anordnungen selbst, lernen, Probleme zu lösen und Fehler zu finden." Und Trauths Idee macht Schule, das Praktikum wächst. Mehr und mehr Kollegen des Instituts wollen auf den Zug aufspringen. Während einer mithilfe eines Magnetsensors das Modell einer römischen Villa aufspüren lässt, planen andere, mit Seismografen Erschütterungen im kleinen Maßstab zu messen. Selbst Ramanspektrometer sollen in absehbarer Zeit in den Kurs Einzug halten. Im neuen Masterstudiengang „Remote Sensing, geoInformation and Visualization" hat sich das Praktikum zum Pflichtmodul gemausert.

Es scheint fast, als hätten die Lego-Macher schon 1975 einen Blick in das Lego-Praktikum von Martin Trauth geworfen, denn damals prägten sie den Slogan, mit dem der Forscher heute seine Studierenden begrüßen könnte: „Mit Lego kannst du mehr."

Martin Trauths Blog über das Lego-Praktikum mit zahlreichen Beispielen und Videos gibt's hier:
http://www.uni-potsdam.de/index.php/category/Lego/

Aus der Sicht der Studierenden

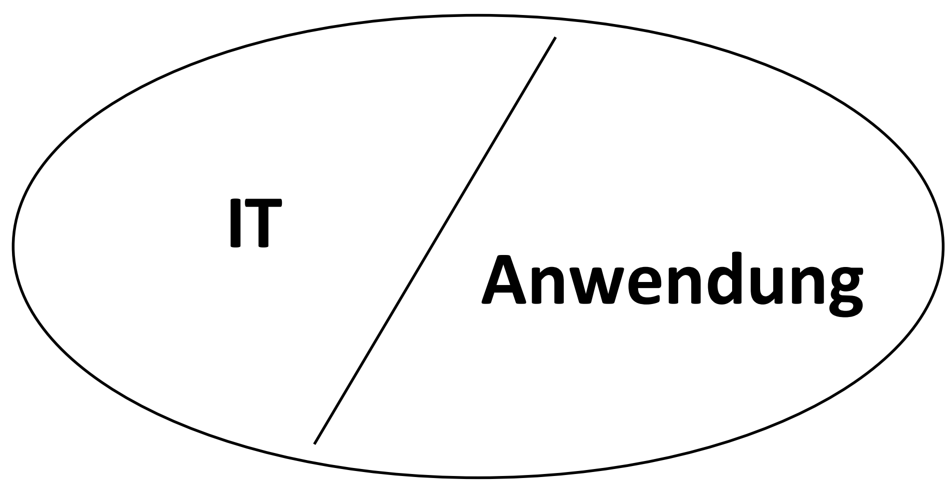
Geowissenschaftliche Fragestellungen

Arbeit mit LEGO
Erstellung von Mini-Modellen

Student

Veröffentlichungen im Blog
Motivation Ergebnisse zu erzielen

Zusammenarbeit mit verschiedenen Fachrichtungen
Geowissenschaftler bis Informatiker



Problemlösendes Arbeiten

Arbeit mit verschiedenen Datenformaten