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CMDT publications

October 6 – 8, 2020

1st International JSXGraph Conference

Book of Abstracts

University of Bayreuth
Center for Mobile Learning with Digital Technology

1st International JSXGraph Conference 2020

University of Bayreuth

Center for Mobile Learning with Digital Technology

95440 Bayreuth

Germany

Conference

The 1st International JSXGraph Conference took place from 6th until 8th of October 2020 and was composed of two tracks, workshop and conference. The online format encouraged fruitful discussion and collaboration among users from all over the world. The schedule respected the location and the timezone of the speakers. The conference was organized by Carsten Miller and Alfred Wassermann from the University of Bayreuth, Germany.

Conference topics

- Usage of JSXGraph
    - for learning / teaching
    - e-Learning environments: moodle, ilias, STACK
    - dynamic visualizations
- Best practices
- Tools
- Presentation of new JSXGraph developments

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Website

The abstracts of the talks at the 1st International JSXGraph Conference are also available on the JSXGraph website:

https://jsxgraph.org/conf

Videos

Most of the recorded videos of the talks can be found on JSXGraph's YouTube Channel:

https://www.youtube.com/@jsxgraph4224

Playlist "1st International JSXGraph Conference"

https://www.youtube.com/playlist?list=PLr10cPSXxWJeffIACvr3mdX-KjvoJ8o86

Talks at the 1st International JSXGraph Conference

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Automatically assessed STACK exercises in Mathematics

Pekka Alestalo

Department of Mathematics and Systems Analysis

Aalto University, Finland

The presentation will be an elementary introduction to creating Math exercises in STACK (= the System for Teaching and Assessment using a Computer algebra Kernel). STACK system offers random generation of questions with wide variety of input types, e.g. mathematical expressions so that the options are not limited to multiple choice. The student's input is automatically checked with Maxima program so that answers algebraically equivalent to the correct one are accepted. This workshop is a useful prerequisite for the more advanced workshop in which we will combine STACK with JSXGraph.

QUESTION **1**

Not complete

Marked out of 1.00

Tidy STACK question tool | Question tests & deployed variants

Solve the differential equation

$$y'' + 11\,y' + 30\,y = 0.$$

Find the characteristic equation of the given differential equation. Use the symbol r for the variable.

$\boxed{} = 0$

The zeros of the characteristic equation are

$r_1 = \boxed{}$

$r_2 = \boxed{}$

Thus the general solution for the differential equation is

$y(x) = C_1 \cdot \boxed{} + C_2 \cdot \boxed{}$

$(C_1$ and C_2 are constants)

Check

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Mobile-friendly JSXGraph

Murray Bourne

Singapore

Mobile devices have outsold laptops and desktops since 2016, and it can be safely assumed the majority of students access their important daily information via their phones. Yet most educational institutions, even in countries with high mobile penetration, continue to present learning materials in formats that only make sense on laptop or desktop devices with large screens. Most JSXGraph examples "in the wild" fall into this category and cannot be appreciated by students while on their phones.

This talk will outline methods for ensuring HTML pages involving JSXGraph are fit for use on a phone. We'll discuss alternatives to setting fixed width and height for the JSXGraph <DIV>, and how to allow for a change of phone orientation. The talk will also cover how to work around some of the quirks of resizing and still produce an acceptable interactive graph that works on all screen sizes. To get most out of this talk, it is assumed you have some basic CSS knowledge, and are comfortable with javascript coding.

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Spirolaterals with the turtle

Alain Busser

Teacher (math and CS) at Lycée Roland-Garros,

Le Tampon, IREMI La Réunion

Professor Frank C Odds, a world leading authority in medical mycology, devised in the 1960s, while he was a student, the beautiful geometric patterns known as spirolaterals.

For a spirolateral, two parameters are required:

– an angle (the rotation of the turtle at each step)

– an number of iterations (or the length of a list of distances at which the turtle travels)

A scientific experiment requires that one repeats the trials while modifying the values of the parameters. This is best achieved with html inputs of type range. As JSXGraph is programmed in JavaScript, I found it easy to make these inputs communicate with the turtle. This allowed to

– publish an interactive presentation of Odds's spirolaterals

– add a variant that Odds devised in the mean time

– add another variant, still invented by Odds

– and seeing this, gave to Odds a new idea

Franck C Odds recently passed out, so this presentation will be a tribute to him.

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Wireless Sensors with ESP32 microcontrollers and JSXGraph

Matthias Ehmann

Arbeitsgruppe Didaktik der Informatik,

University of Bayreuth, 95440 Bayreuth, Germany

Microcontrollers are now powerful, inexpensive small computers. The presentation will show how an ESP32 microcontroller can be used as a data acquisition system that displays the data graphically on a smartphone or tablet. A web server on the microcontroller and JSXGraph are used for this.

Extending JSXGraph with WebAssembly

Michael Gerhäuser

Method Park, Germany

WebAssembly is an open standard for executing non-JavaScript programs inside a web browser. We will explore the possibilities this relatively new technology opens up for JSXGraph developers, content creators and users.

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Promote Equity. Save your students from expensive handheld calculators and boost your remote teaching for math!

Dan Haiem

ClassCalc

ClassCalc is a calculator app with a built-in lockdown browser that lets teachers lock students out of all outside distractions such as instagram, calls and texts, keeping students focused in class, and preventing cheating on tests (even remotely). *ClassCalc fully supports statistics, graphing, scientific and matrices.* ClassCalc's graphing components are built on JSXGraph!

This session will discuss the lack of equity built into our math education system, in terms of 1) The current calculator paradigm, and how high costs are hurting our students, 2) How smartphone calculators are a great solution, but unfortunately, cannot be used during testing and 3) How ClassCalc - our lockdown calculator that allows professors to temporarily lock students on the app during tests/quizzes – is a potential solution for you. By preventing all outside notifications and distractions, ClassCalc turns student phones into a stand-alone calculator. This gives professors/teachers peace-of-mind during tests, and allows students/schools to save money on excessive calculator costs.

https://classcalc.com

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Developing JSXGraph projects in STEMCstudio

David Holmes

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https://stemcstudio.com

STEMCstudio is an exciting in-browser code editor that has been optimized for education and research purposes. STEMCstudio has advanced, yet easy-to-use, features that gently guide the novice programmer towards best practices and mastery while not imposing limitations for experts. In this talk you will learn about the features of STEMCstudio and its benefits that make it an ideal Integrated Development Environment for developing and running your own JSXGraph projects. The format of the talk will be a live coding demonstration, beginning with a high-level walkthrough of how the environment supports the student, educator, and researcher alike. You will learn how to easily evolve an official JSXGraph example written in JavaScript into a TypeScript project with ES6 modules, linting, markdown files, and more. A wrapper API that improves the discoverability of JSXGraph will complete the presentation.

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Authoring STACK questions combined with JSXGraph

Miko Karjalainen

Aalto University, Finland
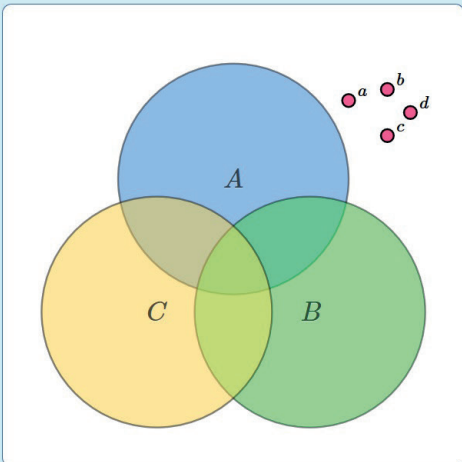
miko.karjalainen@aalto.fi

Workshop

The workshop focuses on how to author more advanced exercises with the STACK system utilizing JSXGraph. The main learning goals are the inclusion of JSXGraph within STACK, how user input can be read and assessed from the graphs and how one can further employ randomly generated question variables in the exercises. In order to participate in this workshop it is advisable to have some preliminary knowledge of the STACK system.

CONwiB Lines - A joint venture between Geometry and Block-based Programming

Dr. Andreas Kirsche

Kirchgasse 1, 99310 Arnstadt, Germany

Construction is a fundamental activity in geometry class. The drafting of construction descriptions supports the mental operation and last but not least makes a contribution to math conception. However, construction descriptions are only effective if they are generated before the construction process. The CONwiB project was launched to maintain this order. The applications of this project ask the user to create a constrution description in first place. This description will be executed by the computer as a program.

In my talk, I will not only give a brief overview of the didactic potential of the applications but also talk about their development using javascript libraries jsxgraph.js and blockly.js.

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Concept for automatic assessment of free body diagrams

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Under the conditions of heterogeneous entry skills of our students we have to augment classical synchronous teaching, be it face-to-face or online, by asynchronous approaches for self-paced individual learning and training. One of these approaches is to provide online exercises with automatic instantaneous feedback.

Therefore, STACK (a system for assessment of mathematics based on a computer algebra) based homework assignments with and without grading stake have been used in the past. The emerging support of JSXGraph from within STACK is the basis for improved exercises, like dynamic sketches, reflecting randomization or students response.

In engineering, a key skill is to communicate using graphs and sketches. Examples from engineering mechanics are free body diagrams or Mohr's circle for 2D eigenvalue problems.

In principle, it is possible to take interactive input in a JSXGraph applet and evaluate it in the context of a STACK quiz. This has been demonstrated in various places. Some applications like the construction of Mohr's circle based on given tensor components are quite straightforward to implement.

However, this doesn't apply to free body diagrams. Providing a general solution for input and evaluation is more involved. The talk discusses basic requirements for such sketches and proposes an author- and user-friendly minimal concept of implementation.

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JSXGraph and STACK: Draw a function and get feedback on your sketch

Tobias Mai

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JSXGraph advertises among other things with the support of dynamic mathematics and the plotting of functions. A not so much advertised strength of JSXGraph is the potential of using the tool together with other software. We use the combination of JSXGraph and STACK (System for Teaching and Assessment using a Computer Algebra Kernel) to create a dynamic learning task that asks students to draw the graph of a function themselves and then provides them with feedback on the graph they have drawn. We would like to present this task and the prototype we developed in detail in our talk at the conference.

In addition to presenting the task itself, we will also introduce the technical details and ideas that led us to develop the task. We will show how we created an environment for drawing the graph with the help of JSXGraph and a few more lines of JavaScript code. We will then explain how we used STACK to evaluate the drawing and provide specific feedback on the quality of the sketch. The evaluation ranges from feedback about whether the sketch of the graph as a whole is sufficiently accurate to information about inaccuracies in individual areas, such as if a zero point has not been sketched accurately. Based on the discussion of the technical implementation, we also show which didactic challenges we faced while designing the task so far and how we have met them. JSXGraph not only supports the task as a means to sketch the graph, but is also helpful in the end in presenting the generated feedback to the students.

This is a project in collaboration with: Alexander Meyer, Santiago Maria Borio Peñaloza, and Chris Sangwin

sketchometry – in touch with geometry!

Carsten Miller

Lehrstuhl für Mathematik und ihre Didaktik

University of Bayreuth, 95440 Bayreuth, Germany

Constructing by sketching … that is the motto of sketchometry. You draw with your finger on a smartphone or tablet screen. sketchometry converts your sketches into geometric constructions, that can be dragged and manipulated. So, sketchometry is a dynamic geometry software with a gesture based user interface. It is the ideal tool for exploring mathematics at school and at home.

The foundation of sketchometry is the JSXGraph library and it is also developed at the University of Bayreuth.

https://sketchometry.org

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Epidemic Model Designer

Konstantinos Panagiotou, Matija Pasch,

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Abstract

Talk: Epidemic Model Designer

Konstantinos Panagiotou   Matija Pasch   Simon Reisser

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Modelling how infectious diseases spread is a research field that has a century long history. From today's viewpoint, which is shaped by the current corona pandemic, the design, analysis and simulation of appropriate models are among the most central and timely research challenges around the globe. Appropriate and adequate epidemiologic models are important and indispensable tools for governments, health departments and physicians.

There is a plethora of available models that describe the dissemination of diseases. In this context, the class of *compartment models* is very popular and plays a prominent and central role. In abstract terms, these models partition the population in disjoint groups called *compartments*, and they specify at which *rates* the individuals make a transition from one compartment to another. The most basic model of this type is the Kermack-McKendrick Model or SIR model:

- there are the three compartments *susceptible* (S), *infected* (I) and *removed* (R);
- susceptible individuals get infected with rate $\beta|I|$, for some $\beta > 0$ and where $|I|$ denotes the number of infected individuals;
- infected individuals get removed (that is, they recover or die) with some recovery rate $\gamma > 0$.

Figure 1 shows the compartment structure and the transition rates, and an example of the evolution of the system with initially one infected and $10^7 - 1$ susceptible individuals.

Compartment models are simple to describe and offer at the same time plenty of flexibility, and this one of the reasons for their immense popularity. In such models it is, for instance, possible to define compartments that distinguish among several types of the severeness of the symptoms; for example, we can distinguish among individuals who have light symptoms and ones that are hospitalized or even need intensive care. Models with a fine grained compartment structure and carefully tuned transitions rates have always been rather popular and have become more so since the outbreak of the corona virus. For a survey see [1].

A compartment model is usually specified as in Figure 1, that is, by utilizing a *weighted directed graph*: the compartments are the nodes, and the directed edges store the appropriate transition rates. Equivalently, the model can be defined with a system of differential equations. For the SIR model, the system is given by

$$S' = -\beta IS, \quad I' = \beta IS - \gamma I, \quad R' = \gamma I.$$

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The right-hand sides of these equations reflect exactly the specified transition rates between the compartments. The three functions S, I, R stand for the (relative) size of the compartments at any given point in time.

When having an appropriate compartment model at hand, there are many fundamental questions that have to be addressed and studied by the developers. What is the effect of the transition rates on the behaviour of the outbreak? What can we
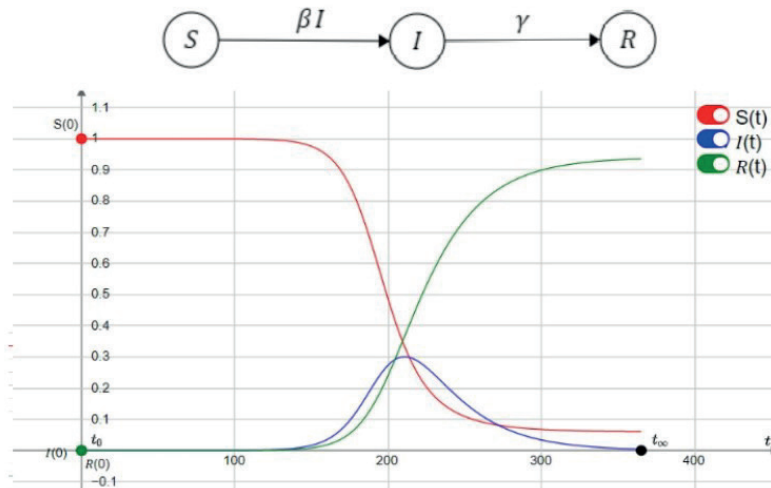

Figure 1: This figure shows the compartment structure and the transition rates of the SIR model and an example of its evolution with $S(0) = 10^7 - 1, I(0) = 1, \beta = 0.12$ and $\gamma = 0.04$. The graph is normalized to 1, i.e the total population is 1 and the number of initially infected is 10^{-7}. From the curves two observations can easily be made: At the peak of the pandemic $\approx 30\%$ of the population will be infected at the same time and at the end less than 10% have never contracted the infection.

say about the rates that hinder an outbreak and how do systems look like that promote the dissemination? What is the effect of changing the rates on the sizes of the compartments? In this work we addressed such questions and developed a system with JSXGraph that allows us to develop graphically a model by adding compartments and specifying the transition rates and the initial sizes of the compartments. The system generates automatically the associated system of differential equations and it determines the evolution of the compartment sizes over a given number of days. Moreover, it allows for real-time adjustment of the parameters/transition rates, so that it becomes very easy to understand their effect on the curves. Finally, the systems allows the user to specify *intervention points*: after a given number of days, the values of the rates can be adjusted. This allows for a detailed study of several containment measures that aim at slowing down the spread of the epidemic. This work is useful for researchers that want to gain a quick and easy insight into any compartment model that they are working on and as well as for teachers that want to demonstrate compartment models and their behaviour on change of input variables. See Figure 2 for an application using the SIR model and Figure 3 for an application using a more involved model taken from a recently published paper.

Technical Implementation This tool has two main parts, a directed graph and a plot. The directed graph is realized as a finite state machine with which the compartment model with its transitions are entered and the underlying differential equations are derived. For its implementation we took inspiration from [2]. The plot is implemented using the JSXGraph library and its rungeKutta method. We added points to change the parameters and added on-click events on them for a responsive feeling.

Live Version A live version of the tool can be found at
`www.mathematik.uni-muenchen.de/~reisser/EMS`.

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[1] F. Brauer, *Compartmental Models in Epidemiology*, pp. 19–79. Berlin, Heidelberg: Springer Berlin Heidelberg, 2008.

[2] E. Wallace, "`http://madebyevan.com/fsm`," 2010.

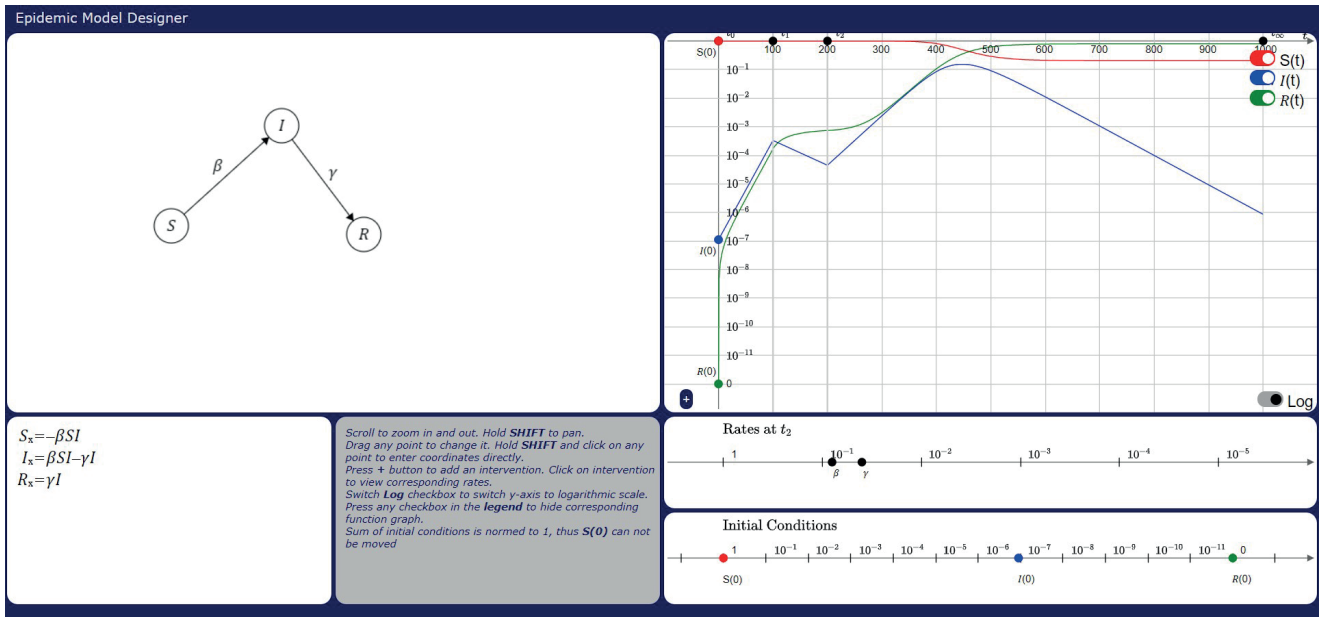[3] S. He, Y. Peng, and K. Sun, "Seir modeling of the covid-19 and its dynamics," *Nonlinear Dynamics*, Jun 2020.

Figure 2: Example Application: SIR model with intervention at time $t_1 = 100$ and $t_2 = 200$. It is $\gamma = 0.04$ at all times and β changes from 0.12 at t_0 over 0.02 at t_1 to 0.08 at t_2. This simulates the start of an epidemic with a high infection rate at the start, then there is a lock-down after 100 day that greatly reduces the infection rates. After another 100 days the lock-down is lifted and replaced with lighter restrictions like mandatory face-masks and social distancing. The graph is display in a semi-logarithmic scale.
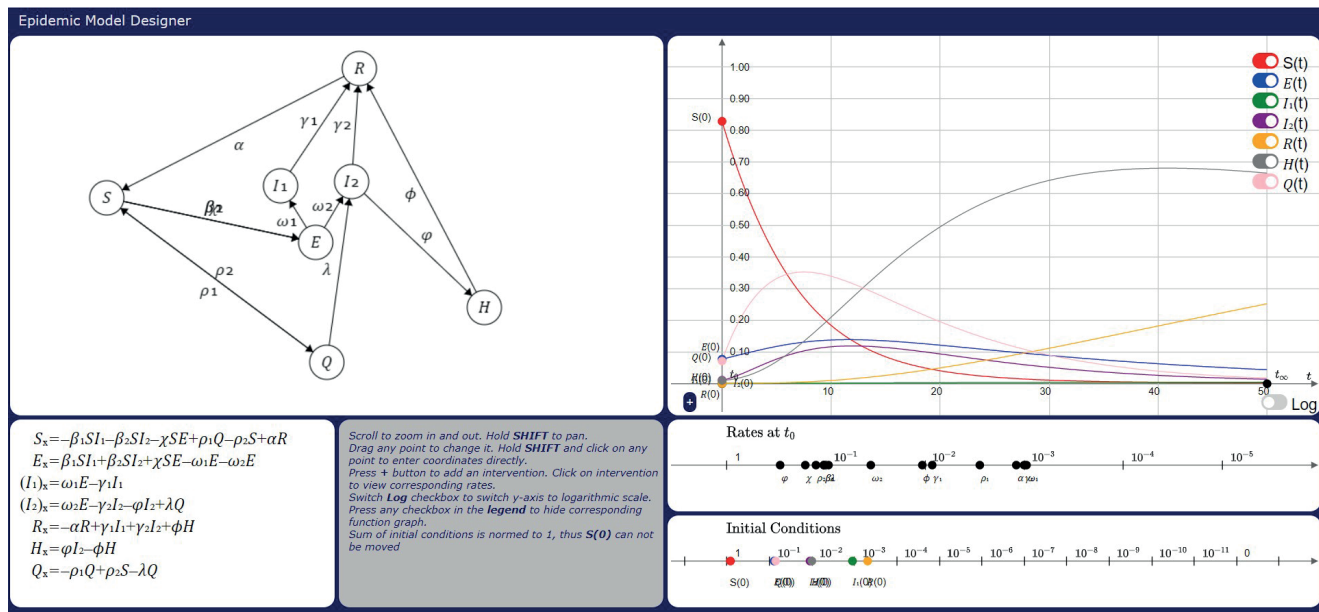

Figure 3: Example Application: SEI_1I_2RQH from [3], where the compartments are Sucseptible, Exposed, Infectious with intervention, Infectious without intervention, Recovered, Quaranteened and Hospitalized. It is used to model the COVID-19 outbreak in Hubei province. Parameters and initial conditions are set to estimates made from real life data in [3].

Teaching Descriptive Statistics using JSXGraph in STACK

Santiago Maria Borio Peñaloza, David Stern,

Danny Parsons, Chiara Facciolà

IDEMS International

James Musyoka

Maseno University

Christine Laetitia

INNODEMS

Over the last few years IDEMS (Innovations in Development, Education and the Mathematical Sciences) International has delivered and provided support for several descriptive statistics courses involving online assessment, including: Descriptive Statistics at Maseno University in Kenya, and Statistical Problem Solving at AIMS Cameroon. The design of questions for these courses was informed by the CAST (Computer-Assisted Statistics Textbooks) project (Stirling, 2010) and focused on analytical and dynamic activities centred around carefully generated data to promote higher order learning. While some of the courses include CAST activities, due to changing technologies these have become less accessible, which has led to a search for alternative delivery mechanisms to extend the access to the impactful CAST exercises (Manyalla, Mbasu, Stern, & Stern, 2014). One such alternative was the JSXGraph integration within STACK (System for Teaching and Assessment using a Computer algebra Kernel), which offers the possibility of generating meaningful data through STACK's underlying computer algebra system Maxima, displaying it through JSXGraph, and assessing answers and providing feedback through STACK. The reimagining of the CAST questions in this way also enables local contextualisation, easier sharing as open educational resources and the potential for further customisation adapted to other contexts.

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This presentation outlines the structures built to enable the development of such questions, illustrating with examples, starting from the creation of statistical diagrams in JSXGraph and its implementation in STACK, using Maxima within STACK to generate data from statistical distributions and feeding it into JSXGraph, and evaluate them using STACK. It will distinguish between questions that assess understanding by extracting information from graphs and answering questions about these, and dynamic questions in which the accurate manipulation of JSXGraph objects is required and assessing the state of graphs after such manipulation. It will also outline how JSXGraph interacts with computer algebra systems, such as maxima within STACK, and argue that there is potential for further growth of JSXGraphs by integrating elements of the Grammar of Graphics ideas developed in (Wilkinson, 1999) and popularised by Hadley Wickham through the well-known GGPlot2 R-Package (Wickham, 2010). The presentation will build on efforts to rethink statistics education (Cobb, 2015) (Stern, et al., 2020) and outline the contexts in which courses are delivered. It will also describe how the same ideas can be applied to courses from secondary school level to postgraduate or professional contexts. Two types of questions have been distinguished: analysing graphs to make inferences and applying statistical concepts to complete graphs. These assess two distinct sets of skills and provide opportunities to develop higher order understanding of statistical concepts. The materials produced, as well as any future content developed, will be published under an Open Educational Resources license and could be shared for integration by other interested education providers, and the presentation will open up the potential for future collaborations with IDEMS to further expand the current question bank and suggest mechanisms for integration of these to other courses.

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JSXGraph for Beginners

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Workshop

This workshop will cover the basics of working with JSXGraph. The nice thing about the JSXGraph is that you do not need to be a programmer to use it. In the workshop, we will talk about the tools and how to prepare the working environment. By constructing the examples, we will cover some basic objects as points, lines, circles, intersections, and angles.

Throughout the workshop, we will use the JSXGraph book, which has been created in the ITEMS project and is freely available on the internet.

https://ipesek.github.io/jsxgraphbook/

https://itemspro.eu

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Visualizing Complex Numbers Using JSXGraph

Andreas Piotrowski

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Germany

Interactive JSXGraph visuals are great tools providing better insights into mathematical concepts, such as complex numbers. Playing around with complex numbers online helps to get a better understanding and sensation of them, both for advanced students and people for whom complex numbers are a sealed book.

In this talk, I will present selected visuals I developed for the platform https://www.bookofproofs.org that I find particularly useful for teachers looking for insightful materials for their students. I will also present the workflow of embedding JSXGraph visuals on the web site, sharing some experiences with developers.

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Usage of JSXGraph in lectures for Math for Engineers

Wigand Rathmann

Friedrich-Alexander-Universität Erlangen-Nürnberg
(FAU), Department Mathematik, Lehrstuhl für
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Students of all technical subjects have to pass a fundamental mathematical education. Different aspects are thereby addressed, as basic logical understandig, analysing linear equation systems, functions or mathematical models, have an idea what calculus means or simply to solve an ODE.

An important point for me is furthermore, that the students will get a picture or a visual impression of mathematical subjects. What does the kernel or the range of a linear mapping mean? What is the difference of an accumulation point an a limit? What does is mean in 2D?

In my presentation I like to present some examples for different mathematical topics like:

– How linear mapping acts on polygon

– Domain and range is not the same

– Sequences in 2d

– Temperature profile in a plate, cylinder and sphere

– Boxplot and dataset

JSXGraph is included in classical HTML-Pages as media content and through dedicated plug-ins for the LMS Moodle and ILIAS. During the "Mathematics for Engineers" (part 1-3) we provide additional material for several topics, e.g. series, (un)-constrained optimization, integration, parametrization of curves and surfaces or differential equations. We see the advantage that the diagrams will become an integral part of the learning modules and the learning unit does not look like patchwork. Further, the learners can focus on the content and do not have to bring additional software or to login in a second learning platform.

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During presence lectures the lecturer can use the same LMS as the learners do for their follow-up work.

All examples will be published for further usage.

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JSXGraph and the Moodle Plug-in Formulas

Marc Bernat Martinez Alemany

BonNouEdu, ITEMS project partner, Spain

Andreas Walter, M.Ed.

Forschungsstelle für mobiles Lernen mit digitalen Medien, University of Bayreuth, D-95440 Bayreuth, Germany

Homeschooling and still tangible geometry experience! This is possible with the JSXGraph Moodle filter. It enables the integration of JSXGraph constructions almost everywhere where HTML elements are used in Moodle. Moodle users can view the constructions, change them with their mouse or fingers and thus experience geometry up close - no matter where they are.

JSXGraph can also be used in a Moodle quiz. An extra component was developed for this, which is delivered together with the filter. It allows teachers to display and even evaluate constructions in formulas Moodle question type.

The Moodle filter is developed together with JSXGraph at the University of Bayreuth and is continuously improved in international cooperation through Erasmus+ ITEMS project.

Basic knowledge of JavaScript is required for this workshop.

https://moodle.org/plugins/filter_jsxgraph

https://itemspro.eu

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Advanced JSXGraph I + II

Alfred Wassermann

University of Bayreuth, Germany

Workshop

In this workshop we will look at various topics of a more advanced flavour. The following topics are planned so far:
– dependent / dynamic elements using functions
– dynamic attributes
– set attribute values
– MathJax
– Include HTML
– Bidirectional communication with DOM
– Constructing with loops
– JessieCode
– Construction dumps

For part II of the workshop we are open to suggestions which topics to discuss.

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Utilizing JSXGraph to Implement John Conway's Game of Life

Leslie Wong

Shenzhen University

Guangdong, China

Motivation

Game of Life is a renowned cellular automation model devised by John Conway, a mathematician at Cambridge. However, when searching "game of life John Conway" at Google Images, it is hard to spot an elegant and appealing implementation. Therefore, as I came across the wonderful JavaScript animation library JSXGraph by chance and was obsessed with its UI, the aspiration to implement game of life by my own was aroused. As a result, I commenced to develop this JSXGraph-version game of life project. https://playgameoflife.live

Proposition Definition

The universe of the Game of Life is an infinite, two-dimensional orthogonal grid of square cells, each of which is in one of two possible states, alive of dead, (or populated and unpopulated, respectively). Every cell interacts with its eight neighbors, which are the cells that are horizontally, vertically, or diagonally adjacent. At each step in time, the following transitions occur:

– For a box with a live cell:
  – There existing fewer than two live neighbors, the cell dies, due to loneliness.
  – There existing more than three live neighbors, the cell dies, due to crowding.
  – There existing two or three live neighbors, the cell lives on to the next generation.
– For an empty box or a box with a dead cell: *There existing three neighbors, the box generates a new live cell, as if by reproduction.
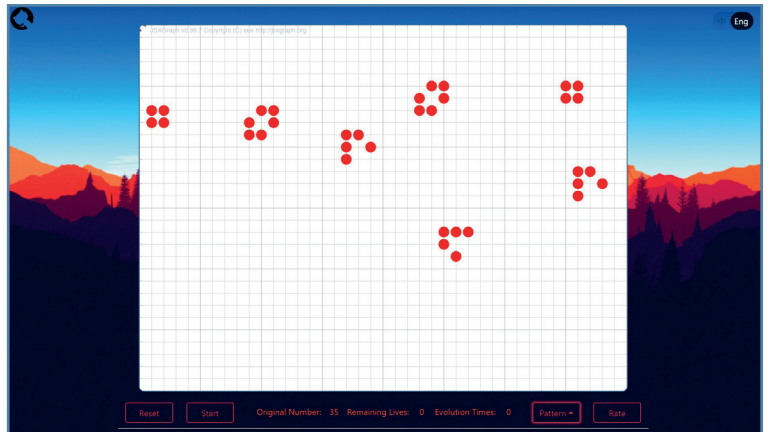
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Project Architecture

The project architecture of my game of life implementation is illustrated as follows.
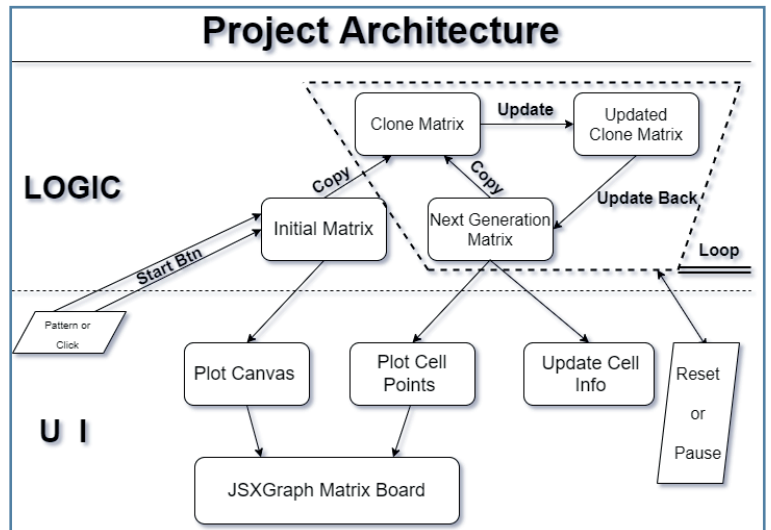
Implementation Result

The snapshot of the implementation result can be seen as follows.

Further Details

For further details, please refer to:

https://github.com/Leslie-Wong-H/game_of_life

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