GeoGebra goes Web

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Abstract

The introduction of smartphones with broadband Internet access allows students to access educational materials from almost everywhere. While the open source software GeoGebra is widely used on desktop and laptop computers, it is currently not available for the majority of mobile touchscreen devices like Apple's iPhone/iPad or Google's Android devices. In our former paper [1] we described the project GeoGebraMobile which aimed to overcome this limitation by making GeoGebra applets accessible to students on a wide range of mobile devices. In our present paper we outline several enhancements of this former work leading to the new GeoGebraWeb project, report on its current status, and describe future plans.

1   Introduction

With the open source educational mathematics software GeoGebra [2] it is possible to create web pages with embedded interactive applets that can be used in a web browser. In [1] we summarized that concerning costs, languages and platforms we focus on free of charge availability, multilingual and platform independent solutions. Previously, GeoGebra applets required a Java plugin to be installed in order to work in a web browser. Since GeoGebraMobile, we are focusing our work on the web browser based platform HTML5 [3] with its programming language Javascript [4] which now allow interactive graphics in a web browser without the need for additional plugins.

In this paper, we explain the development work from the GeoGebraMobile towards its succeeding project GeoGebraWeb [5] which aims to allow the use of fully functional interactive GeoGebra materials on mobile phones, tablet computers as well as standard laptops and workstation PCs.

2   The source unification problem

The GeoGebraMobile version was forked in 2009 from the desktop project and developed independently as a prototype to explore the feasibility of making GeoGebra applets work based on HTML5
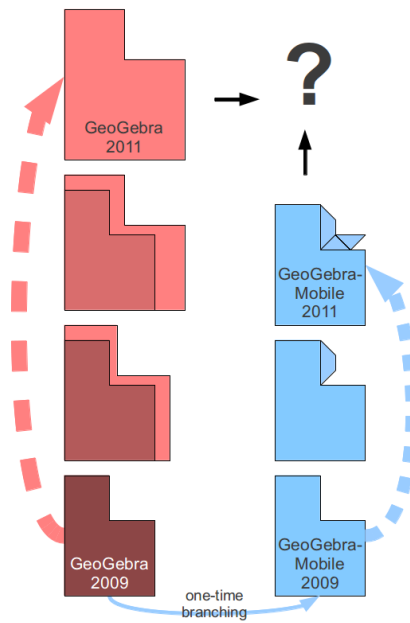
Figure 1: GeoGebra desktop and mobile were two different programs

only without the need of a Java plugin. Thus, the desktop and mobile versions of GeoGebra used to be two different pieces of software with two separated source code trees (Fig. 1). Merging of new enhancements of the desktop version into the GeoGebraMobile fork was very difficult and not really maintainable as the structures of both source code trees differed substantially.

At the International GeoGebra Conference 2011 [6] in Hagenberg, Austria, the core developers decided to completely redesign the source code structure of the desktop and mobile versions. The aim was to use a common code base for the two platforms to enable using all new features of the desktop version in the mobile version as well. The main idea was to split the existing GeoGebra desktop code base into separate parts, the "common" project for the application logic and a new subproject "desktop" for the graphical user interface (GUI). Any other possible user interfaces like the former GeoGebraMobile project should get their own subprojects, relying only on the "common" part, independent from the "desktop".

Since GeoGebra consisted of about 4200 Java files in September 2011, it was not clear if this plan could be implemented in an acceptable period of time with the limited resources of an open source project with only a small developer team.

3   GeoGebraWeb

After two months of planning and experimental work, we finally created the "web" project, based on parts of the GeoGebraMobile code base (Fig. 2), this time not being a fork of the desktop version but a subproject of "common". In order to clearly show this significant restructuring of our source code base, we decided to call this new project "GeoGebraWeb".
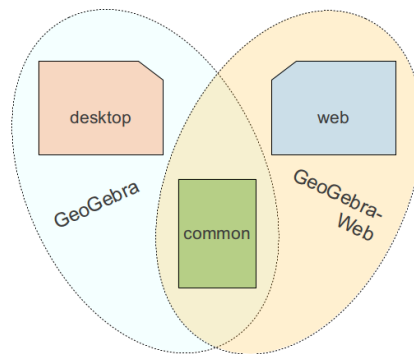
Figure 2: GeoGebraWeb: a new project relying on the "common" GeoGebra kernel

Initially, GeoGebraWeb had fewer features than its predecessor project GeoGebraMobile. However, thanks to financial support by Google Inc. as part of its Chromebook [7] project, we have been able to involve additional programmers, allowing us to make much faster progress than expected.

3.1 GeoGebraWeb Viewer

There has been a high demand from GeoGebra users for establishing a database driven community portal for sharing interactive GeoGebra materials. After about two years of work, the sharing platform "GeoGebraTube" [8] was started in September 2011 and has quickly become the central place for sharing GeoGebra worksheets and related resources. After only one year, GeoGebraTube already contains 20,000 learning resources shared by GeoGebra's user community.

Since March 2012, the GeoGebraTube website is using the GeoGebraWeb viewer to deliver interactive worksheets to devices that do not support Java applets. Right now, GeoGebraTube still serves worksheets based on Java applets to standard computers and laptops running Windows, Mac OS and Linux. However, for Chromebooks, iPads and Android tablets, GeoGebraTube serves worksheets based on the new GeoGebraWeb Viewer in order to make the vast majority of GeoGebraTube worksheets available on these platforms as well. At the moment, the GeoGebraWeb viewer does not support applets showing the algebra view, spreadsheet view or the second graphics view. However, work in this direction is progressing quickly and we expect to completely replace Java applets by the GeoGebraWeb Viewer on GeoGebraTube in 2013. You can already try GeoGebraWeb worksheets from GeoGebraTube on your desktop computer as well by appending `?mobile=true` to the URL of an interactive worksheet like in the example [10].

It is important to note that GeoGebraWeb is fully compatible with GeoGebra's desktop version because they are based on the same source code. All features and improvements of the mathematical logic of GeoGebra in its "common" source code project are part of both GeoGebraWeb and the Java desktop version, thus guaranteeing full compatibility between both versions.

The GeoGebra Java desktop application provides an easy way to upload constructions to the GeoGebraTube portal where we can make sure that the best and latest version of GeoGebraWeb is used no matter on which device the worksheet will be used later. Last but not least, storing and hosting GeoGebra based web worksheets are also more convenient for most users by using a continuously
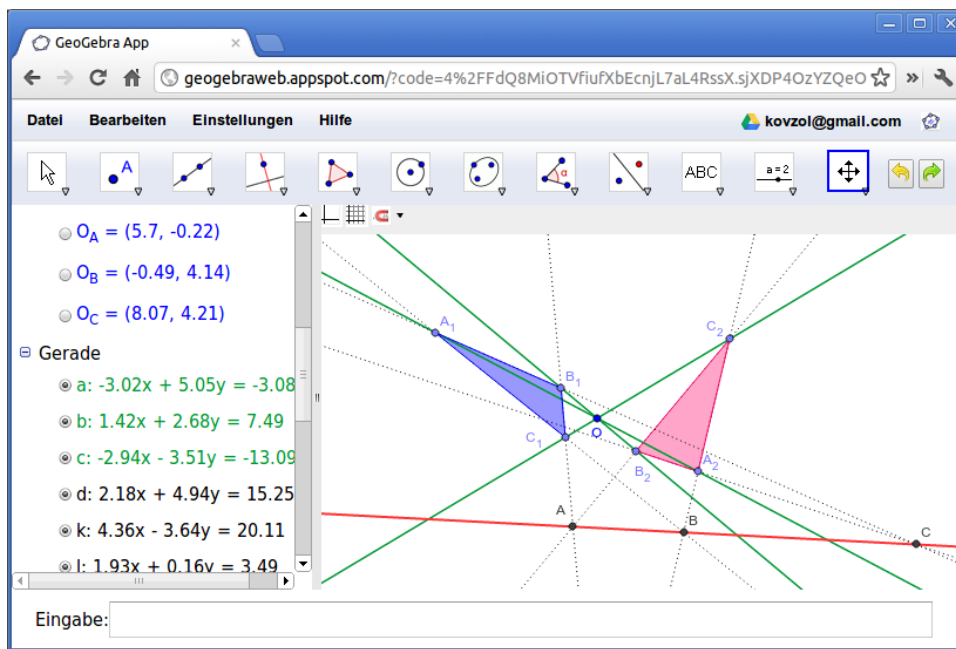
Figure 3: GeoGebraWeb Application showing German language interface

available material-sharing website than installing, configuring, maintaining and updating their own website.

3.2   GeoGebraWeb Application

The March 2012 version of GeoGebraWeb supported interactive constructions using the graphics view but did not yet offer a user interface to create new constructions from scratch. In May 2012, we have published a first version of GeoGebraWeb in Google's Chrome Web Store. This web application includes a fully fledged user interface [12] allowing the creation of new constructions from scratch. It is designed to be used on computers with a mouse and keyboard, running in a standard web browser without the need for a Java plugin. Opening an existing .ggb file is possible by dragging the file from the user desktop into the browser window, or by loading an existing file from Google Drive.

This GeoGebraWeb authoring application interface includes a toolbar that looks and works just like the one in the Java desktop version. We also provided the Algebra View and the Input Bar. Finally, we started to add several menus and menu options. Like in the desktop version, many languages are supported in the menu system, for internationalized commands and object definitions (see Fig. 3).

Currently not all menus of the desktop version are implemented in the web version: file saving, exporting and tool creation are not yet fully supported. On the other hand, there are several new features that use special web technologies. From GeoGebraWeb you can save GeoGebra files to Google Drive and share it with other GMail or Google+ users. If you have a laptop with a webcam, you can capture an image from your camera to include it in a construction taking advantage of unified web standards in modern web browsers [11].
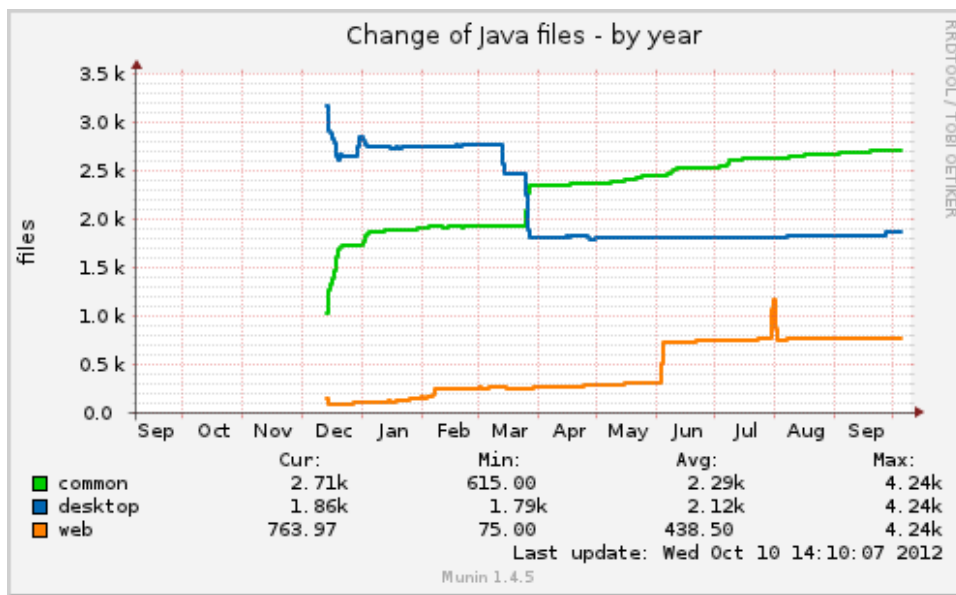
Figure 4: Change of number of Java files between December 2011 and October 2012

4   Some Technical Details

At the moment, the "common" project consists of 2700, the "desktop" of 1900, and the "web" of 800 Java files (see Fig. 4).

Unfortunately the Google Web Toolkit Java to Javascript Compiler (GWT) [13] that we are using to build GeoGebraWeb does not have full standard Java Runtime Environment compatibility [14]. For this reason some parts of the GeoGebra kernel had to be substituted with compatible technologies. It is not straightforward to learn how to work around such problems even for an experienced programmer. This was the main reason we created an automated compilation and testing system for GeoGebra which is capable of notifying when a new error is introduced in the source code. This notification system can report compilation or run-time errors, and regressions in GeoGebra command outputs.

For this purpose we installed a test server at Johannes Kepler University, Linz, Austria. We also set up an automated build system which creates a typical version of GeoGebraWeb by compiling it with several translations and for different web browsers.

To deploy the full version of GeoGebraWeb we are currently using a supercomputer, offered by the JKU Research Institute for Symbolic Computations in Hagenberg, Austria. The compilation takes 30 minutes using 8 threads and 48 GB of RAM, and the deployed version occupies about 800 MB of hard disk on Google's AppSpot server. The main reason for the high demands in processing power is that the Google Web Toolkit creates separate versions for each browser and user interface language. In the future we hope to reduce the build time by implementing our own dynamic language translation module.

5 Conclusion and Future Work

GeoGebraWeb is an HTML5 version of GeoGebra using the same mathematical code base as the desktop version. As the successor project of GeoGebraMobile it is under active development since 2009 and allows the use and creation of GeoGebra worksheets in modern web browsers without the need for a Java plugin, thus making GeoGebra materials from GeoGebraTube available on tablet computers and smartphones as well. All market leading web browsers are very well supported since the Google Web Toolkit creates dedicated Javascript code for each one of them. GeoGebraWeb is fully compatible with the GeoGebra desktop application as they share completely the same Java code base for the kernel.

In the future, we plan to build both our desktop application as well as tablet and smartphone versions based on GeoGebraWeb and HTML5. This has the advantage that we can easily reuse both kernel as well as user interface modules across different devices. At the moment, however, there are hardware and platform related expectations which can only be used from our Java desktop version, including special hardware intercommunication like physics sensors or Microsoft Kinect [15, 16]. Hopefully in the future such pieces of hardware will be directly supported in web browsers. Until then, we will maintain desktop versions running in a Java Virtual Machine as well as in web browsers in parallel.

While GeoGebraWeb already is a stable software, it still needs to be extended to include features like the spreadsheet view, CAS view, and 3D view that are already available in GeoGebra's Java based desktop versions. Furthermore, profiling and performance improvements will be needed to allow fully featured support of constructions on devices with slower processors, in particular smartphones. Work in this direction is already underway based on new profiling tools in the latest Google Web Toolkit versions.

Last but not least, we have recently started work to create a special user interface version of GeoGebraWeb for touch devices as part of the new GeoGebraTouch project (Fig. 5). We hope to release first GeoGebra Apps for iPad and Android in early 2013.

With GeoGebraWeb, teachers and students using GeoGebra can now create and (re)use materials on a wide range of devices ranging from desktop computers to mobile phones.

References

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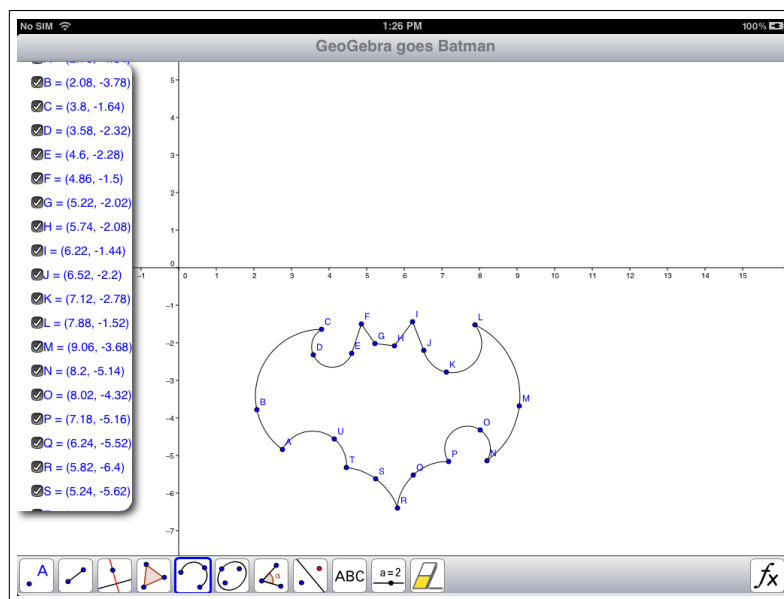
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Figure 5: GeoGebraTouch: prototype of an iPad App in October 2012

[8] GeoGebraTube

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