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A tool for basic surveying and geodetic calculations

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Abstract

With the rapid development of computer and software technologies, many web-based and mobile applications have been developed in recent years. While these programs can occasionally solve extremely basic problems, they can also solve problems that require a great deal of labour and processing power effortlessly. In the field of geomatics engineering, there are some easy problems as well as challenging and work-intensive calculations. Although there are a few web-based and mobile applications in geomatics, these applications are designed to solve only some professional problems. In this study, a web-based tool has been developed to solve almost all problems encountered in surveying and geodetic applications. All coding is written in C# programming language. User-friendly graphical interfaces (GUI) are designed to be easy to use. Sample images have also been added to the modules so that users can better understand the modules. A total of 35 modules were developed, including 20 surveying and 15 geodetic problem solutions. These modules allow surveying and geodetic problems to be easily solved in both student and professional applications. Thus, it saves both labour and time.

1. Introduction

In recent years, the rapid development of computer, software and sensor technologies has led to rapid changes in many occupations. Geomatics engineering is also trying to keep up with this change as quickly as possible. Specifically, lengthy calculations and time are needed for expert accounting operations, which significantly strains colleagues and increases the probability of errors. Geomatics engineering has also experienced a rapid transformation regarding the solution of these problems. First of all, with the digitalization of calculators and the ability to write mini-programs, performing these complex and long-lasting calculations has become much easier and can be completed quickly. These programs have significantly facilitated and shortened surveyors' calculations in the field. The following change occurred with digitalising measuring devices such as total station and levelling instruments. These instruments initially consisted of purely mechanical systems, have become entirely digital and can automatically perform many desired calculations. In these instruments, calculation operations can be carried out by the mini processors and operating systems, and the desired information is produced by programs using raw measurement data.

Geomatics engineering requires the ability to perform many simple and complex calculations. Nowadays, some commercial programs such as Autocad (Url-1), Microstation (Url-2), and Netcad (Url3-) enable us to perform specific calculation transactions as well as project operations. In addition, there are web-based applications developed by institutions such as the National Oceanic and Atmospheric Administration (NGS) Geodetic Toolkit (Url-4) and General Directorate of Mapping of Turkey (Url-5), which allow us to perform only certain calculations. In addition, within the scope of a few academic studies, web-based tools have been developed to solve specific problems. In Cannavo and Palano (2011), a tool was developed in the Matlab program for Geodetic Reference Frame Identification. This tool calculates the velocity values of any point on the earth. There are also applications for similar purposes that can run on mobile devices and can be easily downloaded from the Apple Store and Google Play Store (Url-6). Delic et al. (2014) developed a mobile application using Augmented Reality (AR). The primary purpose of this application is to display geolocation data representing surrounding land parcels. In the application developed for educational purposes, instant communication with teachers is possible thanks to virtual reality technology. Bednarczyk and Janowski (2014) developed a mobile application for levelling.

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With the help of this program, measurements may be taken on the spot and sent to a distant server for processing and report preparation before being stored in a database. A mobile application was developed for coordinate conversion by Hussaini et al. (2023). Additionally, this application also shows instant locations on the map. In Solnyshkova and Dudysheva (2020), a hybrid learning environment, including an interactive virtual teaching tool and mobile application, was developed. As a result, the use of laboratory and field studies in architecture and civil engineering, thanks to the education provided by distance and mobile technologies, was discussed.

The studies above show that web-based or online tools have been developed to solve one or more specific problems. In this study, a tool has been developed that incorporates almost all of the calculations encountered in surveying and geodesy in geomatic engineering. Thanks to this tool, geomatic engineers and surveyors can calculate and check the calculation results to be made and also for our colleagues who forget some calculations or want to do them in a shorter time to access the results quickly.

2. Method

2.1. Coding

Today, many platforms such as C, Python, Java and Matlab are used to create web-based or mobile applications. C is one of the primary programming languages. C++ and C# languages are derived from the C language. Microsoft developed C# in the late 1990s to support the development of the .NET Framework. C# has a rich programming language and is also related to Java.

The entire tools and modules developed within the scope of this study were written in C#. Separate codes were written for all calculations, and a particular module was created for each calculation. All these modules are connected to a single primary tool. An example coding of the developed tool is shown in Figure 1.

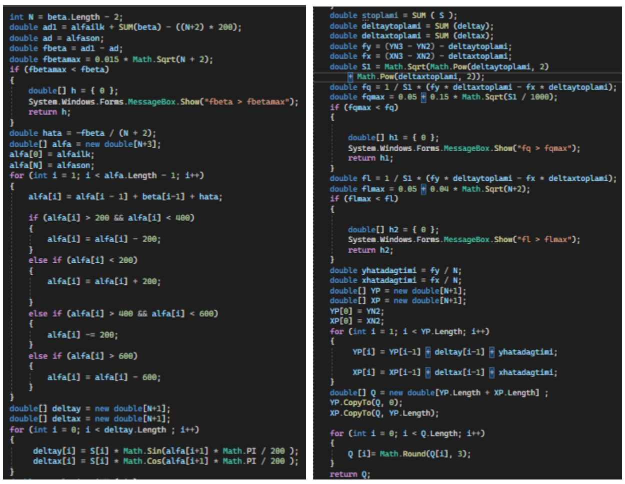

Figure 1. Sample code for the built tool

2.2. Design and Implementations

The developed software consists of a leading tool and modules that can be accessed by clicking on this tool. The mathematical calculations in each module were created using the references in the relevant section below and tested using sample data. Modules are supported with figures so that users can understand the variables given in the modules. The developed web-based tool is divided into two primary parts.

The first part consists of 7 main and 20 sub-modules related to surveying calculations (Figure 2). The first module is related to unit conversion. This module allows easy conversion between angle units (degree, grad and radian) (İnal and Baybura, 1998; Yakar et al., 2019a). The second module addresses processes related to fundamental calculations (İnce and Türen, 2016; Yakar et al., 2019b). This module gives the solutions to four fundamental calculations in a single interface. The third module is related to the traverse calculations (Bektas, 2016; Yakar et al., 2019c). This module covers three types of traverse solutions: open traverse, closed connecting traverse, and closed traverse. The other module includes intersection and resection calculations (Atasoy, 2014). The fifth module was created for reduction to ground calculations (Atasoy, 2014). The sixth module includes setting out calculations: setting out with the polar coordinate method, setting out of the road, vertical setting out, and trigonometric setting out (Baykal, 2009a; Baykal, 2009b; Chilani and Wolf, 2012). Calculations for levelling are given in the seventh section: open levelling traverse, closed connecting levelling traverse, closed levelling traverse, vertical angle calculation, trigonometric levelling, and tower height calculation (Yakar et al., 2020).

The second part consists of 3 main and a total of 15 sub-calculation modules related to geodesy (Figure 3). The first module includes calculations made on the sphere surface: calculations on sphere, orthodrome and loxodrome curves, fundamental calculations on sphere, conversions in between cartesian and geographic coordinates, conversion of cartesian coordinates into geographic coordinates, conversion of geographic coordinates into cartesian coordinates, conversion of geographic coordinates into Gauss-Kruger coordinates, conversion of Gauss-Kruger coordinates into geographic coordinates, and spherical triangle calculation (Bektaş, 2005). Geodetic computations performed on the ellipsoid are given in the second section: conversion of geographic coordinates into cartesian coordinates, conversion of cartesian coordinates into geographic coordinates, and UTM projection (Bektaş, 2021; Kahveci et al., 2021). The last module enables conversion operations between different ITRF datums (Url-7).

3. Conclusion

Geomatics engineering is a branch of science that requires the solution of many numerical problems. Solving these problems sometimes requires very long operations and can take a long time. With the web-based tool implemented in this study, many calculations related to surveying and geodesy that our colleagues encounter can be easily solved. The program's user-friendly interface and sample images make it easy to understand and use. It is planned to develop a mobile application containing these calculations and make it available to our colleagues in the future.

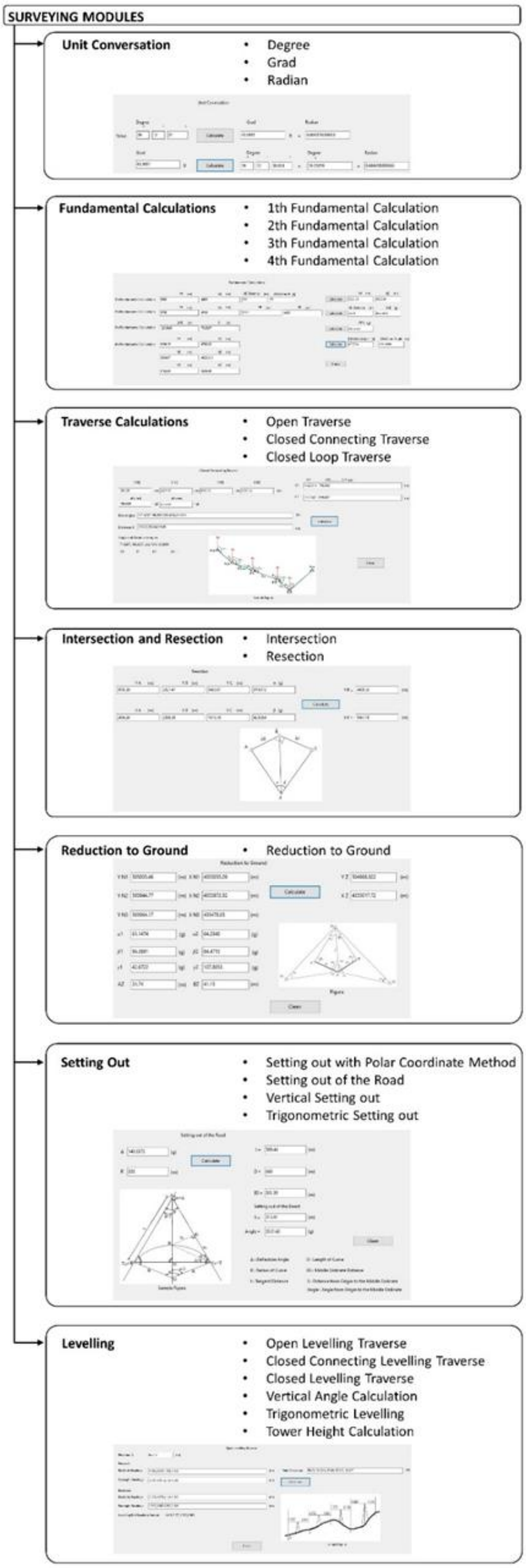

Figure 2. Surveying Modules

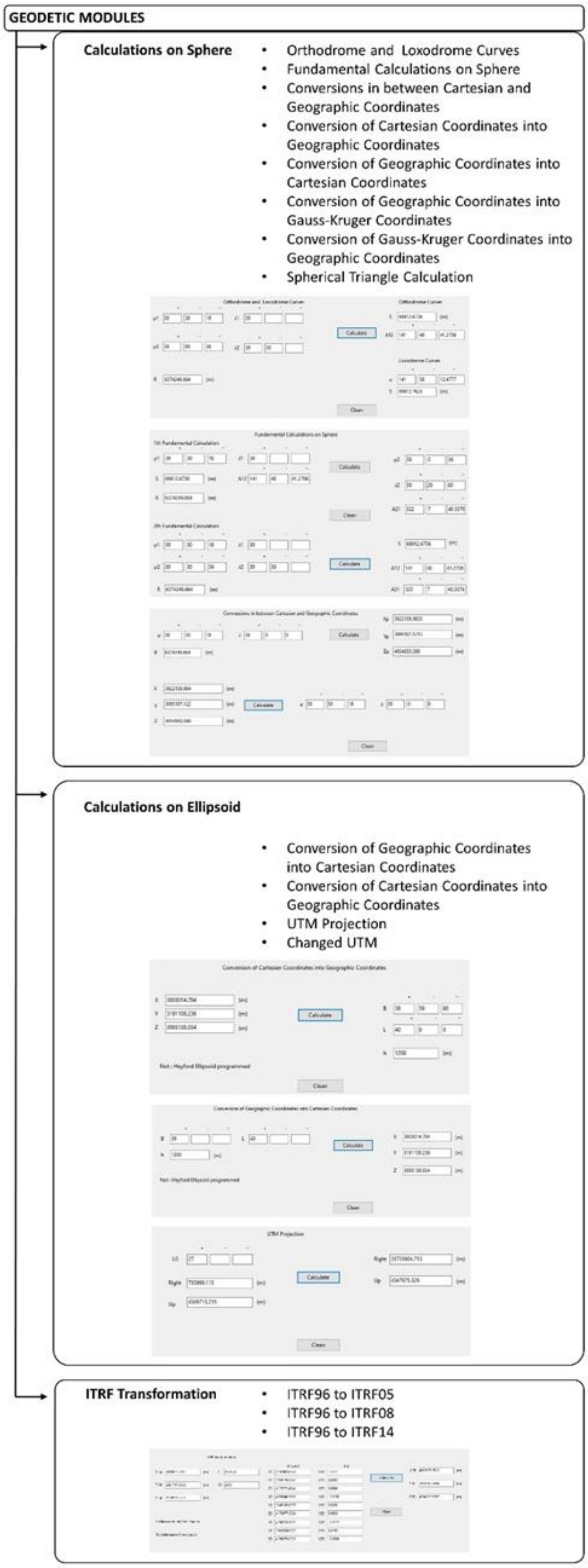

Figure 3. Geodetic Modules

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