GeoS4S Module Geo-Application Development

Burian, J. and Dobesova, Z.
Palacký University Olomouc, Olomouc, Czech Republic
E-mail: jaroslav.burian@upol.cz, zdena.dobesova@upol.cz

Abstract

The rapid development of GIS has enabled the combination or integration of different methods, algorithms, and software (models). This lead to the creation of different types of commercial and open source applications (web, mobile, desktop) that are used for data collection, processing, analysis, and visualization. This teaching module covers geo-application development issues with the focus on mobile and desktop applications development which include tools, models, scripts, and extensions. The module prepares the student to explore the existing application and design a new one for data collection and their automatic processing. This paper describes the learning objectives, lesson content, learning activities and evaluation scheme for this module.

Key Words: Geo-application, Geo-app, Script, Model, Extension, Visual Programming, Python

1. Introduction

Data are important and valuable part of GIS. The collections of data are time and prize consuming. The use of existing free mobile application and their modification speed up data collection. The modification and special purpose design of application make GIS practitioners more flexible. Moreover, the huge amount of data needs the automatic data pre-processing and processing. The visual programming languages (VPL) or textual programming languages could be used for automatic processing. VPL is very suitable for GIS practitioners because they are very comprehensible and it is easy to start using them. More than six different VPLs exist in various GIS. Moreover, Python language as a textual programming language is used for advanced development of the application (scripts) for ArcGIS for Desktop.

1.1 Module Description

Large scale professional and commercial processing and analyses of data require automatization for time-saving and cost-effective application of GIS. This module covers geo-application development issues with the main focus on mobile and desktop applications development which include tools, models, scripts, and extensions. The module is structured with increasing difficulty of programming skills. The students will start with searching and downloading existing solutions, then continue with visual programming, and finish by advanced scripting for data management and analysis in Python language. The module also follows the logical procedure of a typical GIS project which consists of data collection, data management, and data analysis & visualization.

1.2 Learning Outcomes

The students should be able to:

- Search, select, use and modify existing "open" Geo-apps
- Design and develop simple Geo-App for data collection, verify and try it in the field
- Understand advanced techniques of data management and data analysis
- Design and develop advanced tools for data management, data processing and data analyzing in visual programming languages
- Design and develop Python scripts for automatic data processing for ArcGIS
- Solve typical GIS project form the stage of data collection to the data preprocessing and automatic data processing

2. Module Structure

2.1 Module Overview

This module consists of 14 lessons with slides and accompanying notes, plus required and optional reading assignments (Burian et al., 2015 and 2018 and Dobesova, 2012, 2013 and 2014) practice exercises, hands-on interactive and individual assignments, and self-assessment quizzes. The overall student effort is estimated at 150 to 170 hours, and the module is intended to provide credit equivalent to 6 ECTS. The module materials are designed to be used flexibly, in either a traditional classroom setting or for on-line self-study. The module is organized into five sub-modules as described in section 4; the sub-module presentation order can be revised depending on the background and goals of the students.

2.2 Summary of Lesson Content

This section briefly presents the content and goals of each lesson.

- *Lesson 1: Introduction to Geo-app development* – This lesson introduces different types of applications (GeoWeb/Mobile/Desktop Geo-application) and different types of their practical implementation (Extensions, scripts, toolboxes, API).
- *Lesson 2: Overview of selected Geo-app* – This lesson focuses on an overview of selected Geo-app and their resources (ArcGIS Resources, ArcGIS for Developers, GitHub).
- *Lesson 3: Geo-app for data collecting* – This lesson deals with selected mobile applications for data collecting (Survey123 for ArcGIS, Collector for ArcGIS, Open Data Kit).
- *Lesson 4: Automatic Data Processing* – This lesson presents the basic idea of automatic data processing by visual programming language (VPL). The overview of existing visual programming languages in GIS software both commercial and Open Source is presented. The basic graphical vocabularies and examples of visual workflows from each VPL are showed.
- *Lesson 5: Processing Data in ModelBuilder* – This lesson introduces to the basic programming terminology – value, variable, cycle, loop, iteration. It is followed by a) practical creation of workflows (process models) in ModelBuilder for ArcGIS, b) explanation how to create custom toolbox c) how to create parametrical models d) how to use in-line variables in the model.
- *Lesson 6: Data Iteration in ModelBuilder* – This lesson presents the iterators in ModelBuilder. Examples for automatic processing of dataset, automatics processing of rasters and feature classes by iterators are demonstrated.
- *Lesson 7: Data Management for Geo-app development* – This lesson describes advanced functions and tools for vector data analysis/management; and advanced functions and tools for raster data analysis/management.
- *Lesson 8: Spatial analysis for Geo-app development* – This lesson deals with advanced methods for interpolation & spatial statistics, surface analysis, and multi-criteria analysis.
- *Lesson 9: Automatic Data Processing in Open-source sw* – This lesson presents the VPL in QGIS. Basic visual vocabulary and practical workflows in Processing Modeler in QGIS are presented.
- *Lesson 10: Scripting for geodata* – This lesson presents the possible way of user transition from VPL to textual scripting in Python by conversion of models from ModelBuilder to Python scripts. The converted scripts could be extended to advanced scripts subsequently.
- *Lesson 11: Python Scripting* – This module explains the basic set of environments, calling modules in Python scripts for ArcGIS. Finally, the necessary adoption of the new scripts as tools in the custom toolbox is described.
- *Lesson 12: Enumeration methods* – This lesson demonstrate calling "cursor" functions for automatic editing of attribute data by the script. Cursor functions cover also inserting and deleting of records.
- *Lesson 13: Implementation of scripts* – Finishing stage of Python script development is the addition of user help and explanations to the interface. Moreover, the set of script commands for the running messages and the resulting messages to the user are listed.
- *Lesson 14: Geo-app development* – This lesson is focused on management issues connected with geo-app development like software engineering, software development, software release life cycle, project management, time management, product pricing, software maintenance & user support.

3. Hands-on Sessions

The module provides a number of interactive and hands-on activities to supplement the lecture content, deepen students' understanding, and develop their practical skills. Many of these activities are part of the module evaluation scheme.

- *Exercise 1:* Survey Creation in ODK (Lesson 3)
- *Exercise 2:* Model in ModelBuilder for DEM generation (Lesson 5)
- *Exercise 3:* Model in Processing Modeler (Lesson 9)
- *Exercise 4:* Python script for ArcGIS (Lesson 12)
- *Assignment 1:* Exploring existing Mobile Geo Apps and ArcGIS Extensions (Lesson 2)
- *Assignment 2:* Iterators in ModelBuilder (Lesson 6)
- *Assignment 3:* Multicriteria tool Design and Creation (Lesson 8)
- *Assignment 4:* Python script with parameters (Lesson 13)
- *Assignment 5:* Business Model Design (Lesson 14)

This module does not assume any prior knowledge of specific software, although some of the activities will be easier if students have some exposure to programming concepts.

4. Teaching and Learning System

The learning and teaching strategies are student-centered. For each lesson detailed presentation with additional readings, tutorials or manuals will be provided. All processes will be based on e-learning methods. At the beginning of the course (Lesson 1-2), the students will learn about several types of geo-applications, their development, and existing sources of geo-applications. This section is finished by Lesson 3 focused on mobile applications development with practical exercises. The students will learn how to develop a simple mobile app in OpenDataKit solution (Figure 1). The key part of the module deals with the desktop application development (*Lesson 4-9*). For a better understanding of all processes behind the geo-application development, will be necessary to understand basic programming terminology (e.g., value, variable, cycle, loop, iteration, script), but also about advanced techniques of data management/processing/analysis. The development of the task-oriented desktop application will be designed in visual programming languages for ArcGIS in open source software QGIS (Figure 2) and commercial Esri ArcGIS software which is suitable for novice programmers and experts in other fields like an environmentalist, utility engineers, etc. In the case of inaccessibility of Esri software, 60-days trial version with full operability can be used.

In the next set of lessons (*Lesson 10-13*), students will learn how to create and modify scripts for application development. Students will learn the main benefits of using scripts for various opportunities to process and analyze spatial data. Scripting language Python, which has been accepted as the main scripting language for ArcGIS software, will be used for practical tasks (Allen 2014 and Zandbergen 2013).
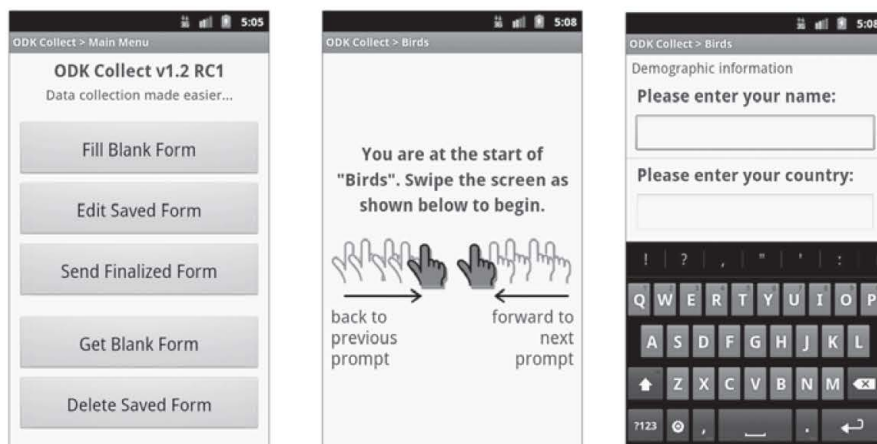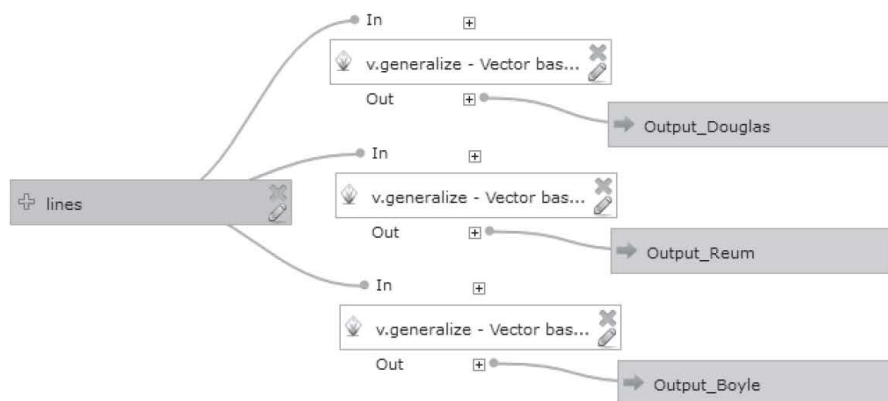
Figure 1: OpenDataKit

Figure 2: Workflow in Processing Modeler in QGIS

Last part of the module (*Lesson 14*) is focused on additional task during application development which includes documentation preparation, application testing, pricing, maintenance, bug reporting, etc. The examples, exercises, and assignments in each part show students how to develop proficiency geo-applications. The hands-on practical training of designing, testing and utilization of geo-application bring the valuable skills for the student.

5. Evaluation System
Students will be evaluated according to their performance in assignments and exercises. All assessments will be based on practical work. The students will solve several programming/scripting problems which increase their knowledge and professional skills. After assessment completion, the students will have access to the prepared examples of the correct solution. In most of the cases there will be more than one good result, so the comparison between student's and teacher's solution will have additional learning value.

6. Additional Notes
The sub-modules in this module are somewhat independent. Students who are using the module material for self-learning rather than for credit may not want to complete all modules. Lesson 1-3 is recommended as a good and useful start for everybody who is interested in gathering data by mobile applications by existing solutions. Lesson 4 about visual programming languages are suitable for beginners in automatic data processing, namely Lesson 9 about VPL in QGIS could be useful for users without license of commercial software ArcGIS. In particular, Lesson 10-13 could be skipped by people who do not have any programming skills in Python language. Lesson 14 could serve as a useful stand-alone summary for people who want to develop proficiency geo-applications. So, the order of sub-models could be swapped or changed according to the sub-modules division in an intensive workshop.

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