Object Oriented Programming Exercises for CS2 Courses: Urban Forestry

Sonya Allin
s.allin@utoronto.ca
University of Toronto Mississauga
Mississauga, Ontario, Canada

Ilir Dema
University of Toronto Mississauga
Mississauga, Ontario, Canada

Oluwagbotemi Iseoluwa
University of Toronto Mississauga
Mississauga, Ontario, Canada

Shuhao Dong
University of Toronto Mississauga
Toronto, Ontario, Canada

Tingting Zhu
University of Toronto Mississauga
Mississauga, Ontario, Canada

ABSTRACT

This document details four short labs designed for CS2 courses (Object Oriented Programming in Java) and related to Urban Forestry. Labs require familiarity with basic OO design and include open city tree inventory data from Vancouver, BC and Mississauga, ON.

CCS CONCEPTS

• **Object Oriented Design**; • **Computer science education**; • **Data science**;

KEYWORDS

CS2, data science, urban forestry

ACM Reference Format:
Sonya Allin, Ilir Dema, Oluwagbotemi Iseoluwa, Shuhao Dong, and Tingting Zhu. 2023. Object Oriented Programming Exercises for CS2 Courses: Urban Forestry. In *Western Canadian Conference on Computing Education (WCCCE '23), May 4–5, 2023, Vancouver, BC, Canada.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3593342.3593347

1 INTRODUCTION

The trees in our urban communities provide us with a wide range of services: food, water regulation and runoff mitigation, carbon sequestration, temperature regulation, noise reduction, and more [6]. Maintaining the health of trees is of significant importance to municipalities.

This document describes four programming labs designed to teach basic principles of object oriented design while exposing students to public data about the urban forest. The reasons for this are many. For one, students in first and second year computer science courses may come from diverse departments like data analytics, data science or biology where large public data sets like tree inventories are common [1]. In addition, as the data is about students' local environment, it has the potential to provide motivation. This is in accordance with Situated Learning Theory, which suggests authentic, real-world contexts promote student engagement [4]. Finally, use cases related to maintenance of the urban forest encourage curriculum links between computing, sustainability and urban planning [2]. Variations of the labs have been used with approximately 450 students enrolled in a CS2 course (Introduction to Software Design) at a large Canadian university. The labs require basic Object Oriented (OO) programming skills, some familiarity with Java syntax, and each is somewhat more complex than the last. In our course, the first lab was introduced after 4 weeks of instruction and subsequent labs were aligned with lecture content. Student ratings of the labs and exercises in this course were strong, based on reviews received for the course at the end of the term.

Assignment handouts been made available in PDF format. For the second lab in the series (which requires GUI programming) we have included maps and data specific to two Canadian cities (Vancouver, BC and Mississauga, ON). In addition, this lab includes links to video tutorials that detail setup and configuration of starter code. A worked solution that leverages hooks to screen readers (e.g. Narrator or VoiceOver) is also included. These additional resources, in theory, afford opportunities to challenge students not only to build visualizations of data about their environments, but to do so in ways that are diversely accessible.

2 THE EXERCISES

While labs expose students to data science for public service, their primary goal to teach software design patterns and Object Oriented Design strategies. The learning objectives of each lab follow.

- Lab 1 teaches basic usage of software objects in Java. In this lab, students are asked to:
  - create "Municipal Tree" objects, attributes and methods;
  - use object methods to perform basic allometric calculations. Allometric equations provide biomass estimates from attributes of trees such as diameter at breast height, height, and/or wood density [5].
- Lab 2 explores GUI programming in Java and Event Handling with JavaFX. In this lab, students are asked to
  - visually display locations on a map;
  - attach "event-handlers" so that users may restrict the view to locations of specific species of tree.
- Lab 3 relates to the "observer" software design pattern. In this lab, students are asked to:
  - create a "broadcaster (observed) object" that can broadcast municipal guidelines for tree planting (i.e. what trees may be planted where);
  - create an "observer object" that can receive broadcasts of municipal guidelines should guidelines change.
- Lab 4 relates to the "decorator" software design pattern. In this lab, students are asked to:

WCCCE '23, May 4–5, 2023, Vancouver, BC, Canada
2023. ACM ISBN 979-8-4007-0789-6/23/05…$15.00
https://doi.org/10.1145/3593342.3593347

- calculate carbon sequestered within the body of specific species of trees (based on biomass calculations);
- "decorate" basic statistics with information about carbon in bark and leaves.

3 INSIGHTS

Calibrating the difficulty of first and second computer science assignments is challenging, in part because students arrive to these courses with very diverse skill sets [3]. Feedback from second year students in the fall of 2022 indicate the second lab to be challenging as a result of the tools required to complete it; the fourth was found to be challenging as it requires independent design thinking and offers less scaffolding to students. We welcome instructors to re-calibrate labs as appropriate, and note that lab content requires some existing familiarity with OO principles.

REFERENCES

[1] Sohail Alhazmi, Margaret Hamilton, and Charles Thevathayan. 2018. CS for All: Catering to Diversity of Master's Students through Assignment Choices *(SIGCSE '18)*. Association for Computing Machinery, New York, NY, USA, 38–43. https://doi.org/10.1145/3159450.3159464

[2] Yu Cai. 2010. Integrating sustainability into undergraduate computing education *(SIGCSE '10)*. Association for Computing Machinery, 524–528. https://doi.org/10.1145/3159450.3159464

[3] James P Cohoon and Luther Tychonievich. 2011. Analysis of a CS1 Approach for Attracting Diverse and Inexperienced Students to Computing Majors *(SIGCSE '11)*. Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/1953163.1953217

[4] Etienne Wenger Jean Lave. 1991. *Situated Learning: Legitimate Peripheral Participation* (2nd. ed.). Cambridge University Press, New York, NY.

[5] Marie-Claude Lambert, C. Ung, and Frédéric Raulier. 2005. Canadian national tree aboveground biomass equations. *Canadian Journal of Forest Research* 35 (2005), 162–170. https://doi.org/10.1139/x05-112

[6] Xiao Ping Song, Puay Yok Tan, Peter Edwards, and Daniel Richards. 2018. The economic benefits and costs of trees in urban forest stewardship: A systematic review. *Urban Forestry Urban Greening* 29 (2018), 162–170. https://doi.org/10.1016/j.ufug.2017.11.017