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# Advanced GIS: Smart Transportation

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NITC
NATIONAL INSTITUTE for TRANSPORTATION and COMMUNITIES

*FINAL REPORT*

# Advanced GIS: Smart Transportation

NITC-ED-850 ■ May 2016

*NITC is the U.S. Department of Transportation's national university transportation center for livable communities.*

TREC
*Transportation Insight for Vibrant Communities*

# ADVANCED GIS: SMART TRANSPORTATION

## Final Report

## NITC-ED-850

by

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16. Abstract

As sensors have become cheaper and more common, they have found an increasingly important role in transportation. However, curriculum to prepare students who will be working with these technologies as developers and planners has not developed at the same rate. The goal of this project was to develop a college course focused around sensors and smart transportation to be offered to undergrad and graduate students at the University of Oregon. The class focused on the practical application and the theoretical consequences of these developments. The class was offered in the spring term of 2015 to a group of undergraduate and graduate students from a variety of backgrounds. An overview of the class is offered here, and course documents are included as appendices so that other educators could use them as a starting point for developing such classes.

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# DISCLAIMER

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# EXECUTIVE SUMMARY

As sensors have become cheaper and more common, they have found an increasingly important role in transportation. However, curriculum to prepare students who will be working with these technologies as developers and planners has not developed at the same rate. The goal of this project was to develop a college course focused around sensors and smart transportation to be offered to undergrad and graduate students at the University of Oregon. The class focused on the practical application and the theoretical consequences of these developments. The class was offered in the spring term of 2015 to a group of undergraduate and graduate students from a variety of backgrounds. An overview of the class is offered here, and course documents are included as appendices so that other educators could use them as a starting point for developing such classes.

# 1.0 BACKGROUND

Sensors have become ubiquitous in our everyday existence. They are common elements in our homes and workplaces, constantly collecting data on our environment and on us. The proliferation of increasingly cheap sensors has allowed for their application in new and exciting ways, but has also stretched existing laws and governance structures as applications that previously had only existed in science fiction are becoming possible. This proliferation of sensors is dramatically changing transportation planning. Sensors are changing the ways that traditional transportation planning functions. In fact, the new paradigm of the smart city has developed because of the availability of new uses of information and sensor technologies for managing and planning cities (Batty et al., 2012).

Though these new applications of sensors have become commonplace within transportation, few classes prepare students to work with and engage critically with these new technologies. The goal of this project was to develop a course curriculum focused on the uses of sensors for smart transportation and to implement this course in the spring term of 2015. Included within this goal were four proposed outcomes: Technical, Pedagogical, Long Term, and Resources. The technical outcome was the development of an online real-time display from the newly installed campus bike counter that would be available to the public. The pedagogical outcome was the development and offering of the course. The long-term outcome is the continued offering of the course in the future. The last outcome is the development of resources to help other instructors develop similar courses elsewhere. This report provides the overview of the course structure and then discusses the outcomes of the course, including a summary of feedback from students who took the course.

# 2.0 COURSE DESCRIPTION AND OBJECTIVES

## 2.1 COURSE OVERVIEW

The goal of the course was for students to explore the ways that sensors can be used to collect data about transportation and how that data can be visualized to provide new insights. The course was focused around transportation, and specifically around a newly installed induction loop bike sensor on campus. This provided a lens to view these issues through and a useful case study.

## 2.2 TOPICS COVERED

The lecture component of the course was co-taught by two instructors. One instructor handled the more theoretical and abstract topics covered in the course. The other instructor dealt with the practical and applied aspects of the course. A list of topics covered included:

- Introduction to Smart Cities
- Overview of Sensors and Senor Networks
- Visualizing and Mapping Sensor Data
- Privacy and Security Issues Associated with Sensors
- Sensor Project Design
- A Sensor Ontology

For lecture, the students were required to engage with readings as well. These readings drew from academic and popular sources to give multiple perspectives on the topics. The syllabus for the course is attached in Appendix A, where the readings and topics can be viewed in greater detail.

In addition to these topics, multiple experts came in to discuss their work. A local planning professional spoke about the ways that their organization studies bicycle behavior around the City of Eugene, and the sort of questions that they need to answer. Another expert who works for an Oregon-based company that builds and installs traffic and bicycle sensors came to explain how these sensors work and the types of applications that they are commonly used for. The third expert, a UO alum, came from an up-and-coming mapping and visualization company to discuss the ways that the company's product could be used to display sensor data. These experts provided additional depth to the course as well as practical experience.

## 2.3 COURSE ASSIGNMENTS

In addition to the lecture, the course had a lab component. As part of the lab, the students completed assignments to further their practical experience with sensor technology. The assignments built up to the final project, where students developed a plan for their own transportation-focused sensor project. They included using a mobile phone mapping application to track and visualize their individual commuting behavior; analyzing biking behavior data and climate data using Tableau, a data visualization platform; and writing a proposal for hypothetical public-transit sensor project. The final project built on these assignments, incorporating a data visualization portion and the development of a sensor project. The students presented their projects in lieu of a final exam. Details on the assignments are given in Appendix B

# 3.0 PROJECT OUTCOMES

## 3.1 STUDENT PERCEPTIONS OF THE COURSE

The course was offered in the spring term of 2015 in the Department of Geography at the University of Oregon. This course drew undergraduate and graduate students from Geography, Planning, Public Policy and Management, Environment Studies, and Product Design, among others. The students who took the course were asked to provide feedback on their experience in order to guide future offerings at the university as well as for this report. The students had overall positive feedback about the course. Many students appreciated the team teaching approach, as it allowed a lot of practical experience to filter into the lectures and discussion. In addition, students appreciated the guest speakers for similar reasons. The students provided some critical feedback as well. Overall, one common critique was that there was not enough engagement with the readings within the class. Also, some students felt that the course assignments were too short, and that either longer or more assignments would have been a better use of the lab. Lastly, there was a lot of feedback about how technical the course was but little agreement. Some students felt that the class was too technical at times, but others felt that more time should have been spent building and working with sensors directly. This is partially the result of the diverse academic backgrounds that the class drew upon.

## 3.2 OUTCOMES

Four proposed outcomes were laid out for this project. Our success at meeting each of those outcomes is detailed below.

### 3.2.1 Technical

One of the proposed outcomes from this project was the development of a web-based interface to allow the public to interact with bike activity across the University of Oregon campus. The goal of building a web-based interface could not be achieved as problems calibrating the newly installed bicycle counter that the project was based around persisted far into the term when the course was being offered. However, students had the experience of developing web-based interfaces for displaying biking data using Tableau.

### 3.2.2 Pedagogical

The second proposed outcome was the offering of the course in the spring of 2015. The course was successfully offered.

### 3.2.3 Long Term

The third goal for this project was the continued offering of the course. The success of the first offering has ensured that it will be offered again during the 2015-2016 academic year within the Department of Geography. The course is being included within the department's new Geospatial Technologies major.

### 3.2.4 Resources

The fourth proposed outcome was the development of pedagogical resources to guide instructors with the development of such courses. To that end, the syllabus and assignments from the course are attached as appendices to this report.

# 4.0 REFERENCES

Batty, M., K. W. Axhausen, F. Giannotti, A. Pozdnoukhov, A. Bazzani, M. Wachowicz, G. Ouzounis, and Y. Portugali. 2012. “Smart Cities of the Future.” *The European Physical Journal Special Topics* 214 (1): 481–518. doi:10.1140/epjst/e2012-01703-3.

# APPENDIX A

# COURSE SYLLABUS

**INSTRUCTORS**

Ken Kato
Associate Director, InfoGraphics Lab
163 Condon Hall
______@uoregon.edu
Office Hours: 2:30 – 3:30, Thursday, Condon 163

Jacob Bartruff
Senior Developer, InfoGraphics Lab
163 Condon Hall
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Office Hours: 1:00 – 2:00, Wednesday, Condon 163
* or by appointment

**TEACHING ASSISTANT**

Rudy Omri
160 Condon Hall
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Office Hours: 12:00 – 1:00, Wednesday, Condon 160
* or by appointment

**PREREQUISITE**

This course lists GEOG 482/582 as the prerequisite – however - ***this can be waived with instructor approval***. This is a new course topic and will not pull heavily from prior GIS experience. If you're comfortable working with data, graphing/visualizing data (ex. Excel), and ready to learn something new contact kkato@uoregon.edu to discuss the course and request a waiver. If you have any previous experience with coding/scripting – great – but it's also not a requirement.

**LECTURES and LABS**

Lecture: Mondays and Wednesdays, 10:00am – 10:50am in Condon 206 (CRN 32418).

Lectures are **Mondays** and **Wednesdays**. The lectures will be structured to explore a new topic each week. The Monday lecture will initiate the topic and introduce the big picture concepts, led by Ken Kato – Associate Director of the InfoGraphics Lab. The Wednesday lecture will take the topic further, looking deeper under-the-hood, to explore the technical side the topic — looking at the APIs, code, systems architecture, methods, etc, led by Jacob Bartruff – Senior Developer of the InfoGraphics Lab. The readings are posted below. The readings will prepare you for the lecture and discussion.You are expected to have completed the readings prior to the lecture for which they are listed. The readings are all available online (linked below). In general, the readings will consist of one academic article and one mainstream media article on the topic.

Lab: Tuesdays 11:00am – 12:50pm (CRN 32419) and 1:00pm – 2:50pm (CRN 32420) in McKenzie 445.

**GRADING**

**491:**
Assignment 1 = 15%
Assignment 2 = 20%
Assignment 3 = 25%
Assignment 4 = 40%

**591:**
Assignment 1 = 10%
Assignment 2 = 15%
Assignment 3 = 20%
Assignment 4 = 40%
Lit Review Paper = 10%
In-Class Presentation = 5%

**GRADING RUBRIC**

**A+ (97% and greater)** Only used when a student's performance significantly exceeds all requirements and expectations for the class. Typically very few to no students receive this grade.
**A (90% to <97%)** Excellent grasp of material and strong performance across the board, or exceptional performance in one aspect of the course offsetting somewhat less strong performance in another. Typically no more than a quarter of the students in a class receive this grade, fewer in lower-division classes.
**B (80% to <90%)** Good grasp of material and good performance on most components of the course. Typically this is the most common grade.
**C (70% to <80%)** Satisfactory grasp of material and/or performance on significant aspects of the class.
**D (60% to <70%)** Subpar grasp of material and/or performance on significant aspects of the class.
**F (<60%)** Unacceptable grasp of material and/or performance on significant aspects of the class.

**EXPECTATIONS**

- Submit your assignments on time. Late assignments will be penalized 50%. Assignments will not be accepted after 7 days past the submission deadline.

- Your final project will not be accepted after the submission deadline. You will receive a 0% if it is not submitted on the assigned deadline.

- Do not plagiarize your work. Make sure that you give credit where credit is due. Please visit UO's Plagiarism website for more details: http://library.uoregon.edu/guides/plagiarism/students/index.htm

**ACCOMMODATIONS**

The University of Oregon provides individuals with disabilities reasonable accommodations to participate in educational programs, activities, and services. Students with disabilities requiring accommodations to participate in class activities or meet course requirements should first contact the Accessible Education Center (164 Oregon Hall, 346-1155), and then contact me as soon as possible.

**SCHEDULE**

**March 30**
Lecture 1: Course Introduction

**April 1**
Lecture 2: Smart Cities
Reading: #1. Smart cities of the future (download full PDF).
#2. Can We Trust Smart Cities? (read all five sections).
Your Thoughts: *Below is the word cloud based on the terms you wrote down in class.*

**April 6**
Lecture3: Big Data generated by the Sensors of a Smart City
Reading: #1. The real-time city? Big data and smart urbanism (download full PDF). #2. Big Data basic concepts and benefits explained

**April 8**
Lecture4: How do sensors & sensor systems work
Reading: #1.Wireless Sensor Networks – An Introduction.
#2. SmartSantander – The City of Santander's Sensor Network Facility

**April 13**
Lecture5: Visualizing sensor data
Reading: #1. Visualizing Sensor Data.
#2. To Go from Big Data to Big Insight, Start with a Visual
Your Thoughts: *Below is the word cloud based on the terms you wrote down in class.*

**April 15**
Lecture6: Mapping sensor data
Reading: #1.The New Cartographers – How a Mapping Renaissance Is Changing the Way We See Cities
#2. Spatial is Indeed Special

**April 20**
Lecture7: A sensor ontology
Reading: #1. A Sensor Classification Scheme.
#2. Ontology of the W3C Semantic Sensor Network Incubator Group.
#3. Sensors by Category.

**April 22**
Lecture8: Sensor showcase
Reading: #1. Everything You Ever Wanted to Know About Arduino and Raspberry Pi

**April 27**
Lecture9: Project Design – What special considerations are necessary for projects employing sensors?
Reading: #1. The effect of weather and climate on bicycle commuting.
#2 Estimating Annual Average Daily Bicyclist and Analyzing Cyclist Safety at Urban Intersections. *You don't need to read the entire document. Read Chapters 2 and 3 of this dissertation for an excellent presentation of her project design. By all means… read the entire document… or if you're wanting to go a little deeper – read Sections, 4.10, 4.11, 6.1.1, 6.1.2, 6.2.1 – 6.2.3.*

**April 29**
**Lecture10** Sensing Location – a look under the hood at Geofencing
Reading: #1. Why does a smart city need to be spatially enabled?

**May 4**
Lecture11: Privacy and security issues — what are the implications of millions of interconnected sensors continuously broadcasting data and what is the "internet of things"
Reading #1. Smart City Technology May Be Vulnerable To Hackers
Reading #2.Privacy risks emerging from the adoption of innocuous wearable sensors in the mobile environment – download the PDF (p11-raij) for easier reading.
Reading #3 ODOT embarks on "big data" project with purchase of Strava dataset

**May 6**
Lecture12: Sensing Presence – – a look under the hood at Bluetooth Low Energy
Reading: TBA

**May 11**
Lecture13: Your Sensor Project and Security and Privacy Part II. We will introduce your final project/assignment. How will we pull data from the Campus Bike Counter? How will we visualize this live data feed? What other sensor data should we integrate to explore bike transportation at the University of Oregon. How will we publish our real-time data feeds? We will also conduct a group discussion on the Security and Privacy issues we covered in Lecture 11 but also consider moral and ethical perspectives of sensor-driven Smart Cities.
Reading#1: Smartmentality: The Smart City as Disciplinary Strategy
Reading #2:"If I look at the mass I will never act": Psychic numbing and genocide by Paul Slovic.

**May 13**
Lecture14: Guest lecture with Josh Roll, Data & Modeling Coordinator from Central Lane Metropolitan Planning Organization. Josh will present how local planning staff are using bike traffic count data in GHG, health, and fuel consumption analysis work
Reading #1: Understanding and Measuring Bicycling Behavior: a Focus on Travel Time and Route Choice

**May 18**
Lecture15: Project Workshop
Group work session – breaking down your project proposals and providing peer review.

**May 20**
**Lecture 16**: Guest Lecture with Lyzi Diamond from Mapbox Education. Lyzi is also co-founder of Maptime, a beginner-oriented learning environment geared toward maps and programming with chapters all over the world. Before joining Mapbox, Lyzi was a fellow at Code for America working with city governments to help them better use technology. She holds a dual degree in Geography and Planning, Public Policy, and Management from the University of Oregon — an alum of the UO InfoGraphics Lab.

**May 25**
**No class – Memorial Day**

**May 27**
Lecture 18: Guest lecture with Colin Gibson, VP of Product Development – Diamond Traffic Products. Colin developed the bike counting sensor for campus. He will open up the hood and discuss the type of sensor employed for this project – what is actually being measured/sensed to detect a bike why this is challenging – compared to cars – and specifically our location.

**June 1**
**Lecture 19**: Graduate Student Presentations.

**June 3**
**Lecture 20**: Graduate Student Presentations and Course Evaluation discussion with Professor Chris Bone.

**June 11**
**FINAL:** Presentations 10:15 – 12:15 in 206 Condon Hall

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