Geospatial Vision and Visualization

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Lecture 1

Today's Topics

- Course Overview

- Digital Mapping State of the Art

- Next Generation Mapping Technologies

Course Overview

Instructor Biography

- **Education**

  - University of Notre Dame (Ph.D. and M.S.)

  - University of Science and Technology of China (B.S.)

- **Research**

  - Computer Vision; digital mapping

- **Director of Engineering, HERE Technologies**

- **Adjunct Professor and Ph.D. Advisor at Northwestern and IIT**

Motivation

- **Location, Location, Location**

  - Internet mapping services: Google, Microsoft, Apple

  - Acquisitions

    - Nokia > NAVTEQ $8.1B; 2008

    - TomTom > TeleAtlas $3.2B 2008

    - Alibaba > AutoNavi $1.5B 2014

    - German car consortium > HERE $2.8B 2015

    - Tencent/NavInfo/GIC to buy 10% of HERE 2017 (US Government rejected it)

    - Intel bought 15% of HERE 2017

    - Bosch and Continental each to buy 5% of HERE in 2018

    - Intel bought Mobileye for $15b in 2017 and invested in HERE Technologies

    - Mitsubishi and NTT invested in HERE Technologies

    - Many map company acquisitions by Google, Apple, Uber, Amazon, etc.

  - Free mobile navigation: Android, iOS, Windows, others

  - Automated driving

  - Big impact: safety, fuel efficiency, homeland security

Motivation

- **AI for the Geospatial Industry**

  - Automation

  - New content and services

- **Geospatial Visualization**

  - 3D, large scale

  - Multi-modal

Motivation

- **Addition of Software Specially Designed To Automate the Analysis of Geospatial Imagery to the Export Control Classification Number 0Y521 Series**

- Geospatial imagery "software" "specially designed" for training a Deep Convolutional Neural Network to automate the analysis of geospatial imagery and point clouds, and having all of the following:

- 1. Provides a graphical user interface that enables the user to identify objects (*e.g.,* vehicles, houses, etc.) from within geospatial imagery and point clouds in order to extract positive and negative samples of an object of interest;

- 2. Reduces pixel variation by performing scale, color, and rotational normalization on the positive samples;

- 3. Trains a Deep Convolutional Neural Network to detect the object of interest from the positive and negative samples; and

- 4. Identifies objects in geospatial imagery using the trained Deep Convolutional Neural Network by matching the rotational pattern from the positive samples with the rotational pattern of objects in the geospatial imagery.

- *Technical Note:* A point cloud is a collection of data points defined by a given coordinate system. A point cloud is also known as a digital surface model.

Goals

- **Real World Problems and Data**

- **Next Generation Digital Mapping Technologies**

- **Computer Vision in Digital Mapping**

- **Visualization for 3D Geospatial Content**

- **Skill Set Desirable for Future Employers**

- **Internship and Full-Time Job Opportunities**

- **Research Collaborations with faculty members and students**
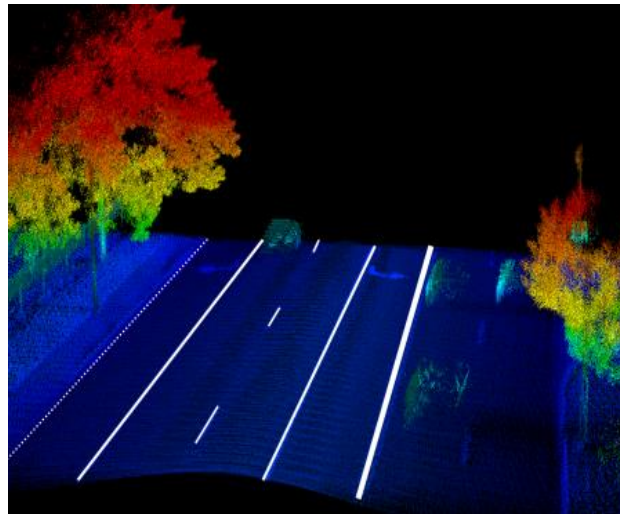
Course Content

- **Digital Mapping**

  - **Overview of Maps**

  - **Global Positioning Technologies**

  - **Geospatial Data Acquisition and Processing**

  - **Next Generation Map Making**
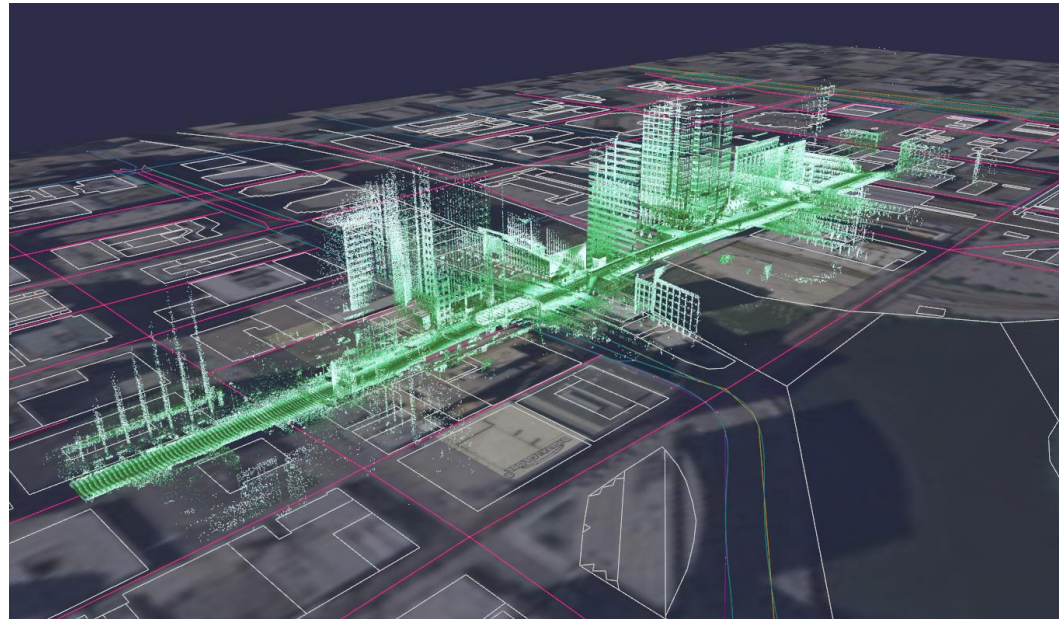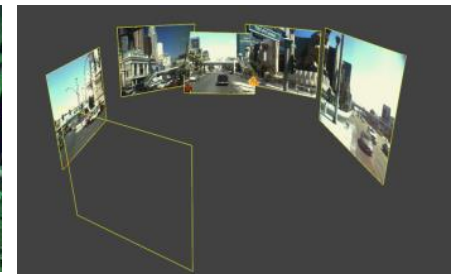
Course Content (cont.)

- **AI for the Geospatial Industry**

  - **Big data: Panoramic, Satellite, 3D, LIDAR, RADAR, probes, etc**

  - **Automatic Feature Extraction**

  - **3D Vision**

Course Content (cont.)

- **Visualization of Geospatial Content**

  - Street view

  - 3D point cloud

  - 2D and 3D registration

  - Integration of multiple modalities

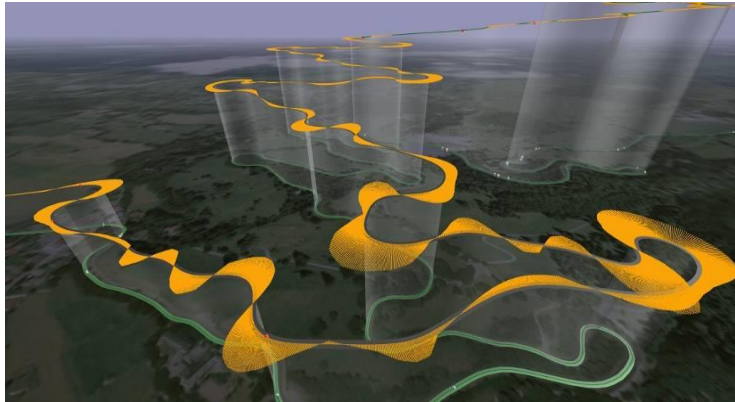 - Real-time manipulation of large-scale data

ACM Multimedia 2010 demo

Course Content (cont.)

- **Case Studies**

  - **Geospatial Content for automated driving and ADAS**

  - **Geo-tagged Mobile Probe Data Mining**

  - **Privacy Protection in Geospatial Content**

  - **3D maps for smart cities**

Syllabus

1. Course overview, digital mapping state of the art
2. Streetview and image processing – Assignment 1
3. GPS and probe data – Assignment 2
4. Image mosaics and panorama – Assignment 3
5. 3D Sensing
6. Point Cloud Processing
7. Object extraction
8. Case studies: HD Maps for Automated Driving
9. Project presentation

Course Logistics

- **Prerequisites**

  - **Linear Algebra, Calculus, Data Structures**

  - **Working knowledge of Matlab or C/C++ or willingness + time to pick it up quickly**

  - **No image processing, computer vision, computer graphics, visualization or cartography experience is assumed**

- **Readings**

  - **No required text**

  - **Papers/Articles (to be assigned in class)**

Grading (subject to change)

- Class participation (20%) - individual

- 1 in-class presentation (15%) - group

- 3 Homework Assignment (45%) - group

- 1 class project (20%) - group

Any programming language or Matlab is fine for homework and project.

Course Policies

- **Late Policy**
  - All homework/projects are due before class. No late homework/projects will be accepted (resulting in a 0 grade for any such late homework/projects). Please contact the instructor before the deadline if you have any questions.

- **Attendance Policy**
  - On time attendance is required. If you arrive in class late or leave early, this will count as an absence. Students who need to be absent should notify the instructor with reasonable excuses before the class starts. More than 2 absences will result in a 0 participation grade.

- **Data Usage Policy**
  - The data provided for this course can only be used for class homework and projects. The data cannot be released to other parties outside the class.

- **Collaboration Policy**
  - Collaboration is encouraged for course homework and projects but students should comply with university's honor code.

Acknowledgement

- **The instructor is grateful to Dr. Li Zhang (Google) for providing some of the course resources**

Heads-up

- I am a working director and I sometimes travel for work. Please be flexible with make-up lecture schedule as I will do my best to accommodate your schedule as well.

- This is a three hour weekly lecture. I will make it as interactive as possible. I strongly encourage you to participate in class discussions and group presentations. Please feel free to offer any suggestions you have for course content.

- I will not cover programming during our lectures but I am happy to address any questions you have regarding programming outside class.

Heads-up - Whether you should take this course

- I do give grades of B, C and F in addition to A

- If you cannot attend the lectures on time for multiple times this is not for you

Questions regarding this course?