

Machine Learning for Signal Processing Project Ideas

Lab 1. 4 Sep 2018
Instructor: Najim Dehak

520-612 1

Course Projects

- Covers 30% of your grade
- 10-12 weeks of work
- Required:
 - Serious commitment to project
 - Extra points for working demonstration
 - Project Report
 - Poster presented in poster session
 - Last day of courses
 - Graded by anonymous external reviewers in addition to the course instructors

520-612 2

Course Projects

- Projects will be done by teams of students
 - Ideal team size: 4
 - Find yourself a team
 - If you wish to work alone, that is OK
 - But we will not require less of you for this
 - If you cannot find a team by yourselves, you will be assigned to a team
 - Teams will be listed on the Blackboard
 - All currently registered students will be put in a team eventually
- Will require background reading and literature survey
 - Learn about the problem

520-612 3

Projects

- Team group list deadline is September 13th.
- Teams must inform us of their choice of project by 26th September 2016
 - The later you start, the less time you will have to work on the project

520-612 4

Quality of projects

- Project must include aspects of signal analysis and machine learning
 - Prediction, classification or compression of signals
 - Using machine learning techniques
- Few projects from previous year have led to publications

520-612 5

Quality of projects

- Several CMU projects from previous years have led to publications
 - Conference and journal papers
 - Best paper awards
 - Doctoral and Masters' dissertations

520-612 6

JHU Projects from past years: 2017

- Exploring Neural Functional Connectivity in Brain Tumor Patients
- Predicting Radiation Induced Toxicities in Radiotherapy using Spatial Dose Distributions
- Speech Biomarkers for Automatic detection of Parkinson's disease
- Human Face Detection and Attributes Identification Based on DenseBox
- Simultaneous Use of Multiple Biomarkers and Other Risk Factors for Cardiovascular Event Prediction
- Auditory Attention Using EEG
- Neural Network Based Mask Estimation for Single-Channel Speech Enhancement
- SII5: Speech to Image
- Decoding motor movements using non-motor brain areas
- Hybrid Networks with Spatial Encoding for 3D Segmentation
- Tumor Segmentation in PET Images of Lung Cancer Patients Using Deep Learning
- Transcription of the American Sign Language

520-612 7

JHU Projects from past years: 2016

- So who writes out these notes?
- Exploring Land Use Imagery with Clustering Techniques
- Predicting behavioural score for ASD
- Unsupervised Temporal Trajectory Learning and its application in Sound Identification
- Speaker Recognition with Deep CCA
- Convolutional Neural Networks for Analyzing Photoacoustic Images
- Gender Classification Using Frontal Image
- \$W"A'M: A Music Score Reader

520-612 8

JHU Projects from past years: 2016

- End to End Learning for Self-Driving Robots
- The Gambler's Tell Analyzing neural data to decode a player's hand of cards
- Offline Signature Verification
- Radio Eye
- 2D Indoor mapping/tracking using a smartphone
- Classification Based on Image Contrast
- Analysis of EVs and Power Grid in Machine Learning Method
- Deep Neural Networks for Text-independent Speaker Verification
- Cursor Control with sEMG

520-612 9

CMU Projects from past years: 2015

- So you think you can sing? : Fixing Karaoke
- Self-paced learning in multimedia event detection with social signal processing
- Improving intonation in audio book speech synthesis
- Your keyboard is not your friend: reading typed text from audio recordings
- Learning successful strategy in adversarial games
- Gesture phase segmentation
- Electric load prediction for airport buildings
- Unsupervised template learning for birdsong identification
- Realtime keyword spotting in video games

520-612 10

CMU Projects from past years: 2015

- Loop querier – searching the rhythmic pattern
- Vision-based montecarlo localization for autonomous vehicle
- Beatbox to drum conversion
- City localization on flickr videos using only audio
- Facial landmarks based video frontalization and its application in face recognition
- Audioshop: Modifying and editing singing voice
- Predicting and classifying RF signal strength in an environment with obstacles
- Realtime detection of basketball players

520-612 11

CMU Projects from past years: 2014

- IMPROVING SPATIALIZATION ON HEADPHONES FOR STEREO MUSIC
- PREDICTING THE OUTCOME OF ROULETTE
- FACIAL REPLACEMENT IN VIDEOS
- ISOLATED SIGN WORD RECOGNITION SYSTEM
- ACCENTED ENGLISH DIALECT CLASSIFICATION
- BRAIN IMAGE CLASSIFIER
- FACIAL EXPRESSION RECOGNITION
- MOOD BASED CLASSIFICATION OF SONGS TO IDENTIFY ACOUSTIC FEATURES THAT ALLEVIATE DEPRESSION
- PERSON IDENTIFICATION THROUGH FOOTSTEP-INDUCED FLOOR VIBRATION
- DETECT HUMAN HEAD-ORIENTATION BASED ON CONVOLUTIONAL NEURAL NETWORK AND DEPTH CAMERA
- NEURAL NETWORK BASED SLUDGE VOLUME INDEX PREDICTION

520-612 12

CMU Projects from past years: 2014

- 8-BIT MUSIC NOTE IDENTIFICATION - TURNING MARIO INTO METAL
- STREET VIEW HOUSE NUMBER RECOGNITION BASED ON CONVOLUTIONAL NEURAL NETWORKS
- TRAIN-BASED INFRASTRUCTURE MONITORING
- MANIFOLD INTERPOLATION OF X-RAY RADIOGRAPHS
- A SMARTPHONE BASED INDOOR POSITIONING SYSTEM AUGMENTED WITH INFRARED SENSING
- ROCK, PAPER, SCISSORS -- HAND GESTURE RECOGNITION
- LANGUAGE MODELS WITH SEMANTIC CONSTRAINTS
- LEARNING TO PREDICT WHERE A DRIVER LOOKS
- REAL TIME MONITORING OF STUDENT'S LEARNING PERFORMANCE

520-612 13

CMU Projects from past years: 2013

- Automotive vision localization
- Lyric recognition
- Imaging without a camera
- Handwriting recognition with a Kinect
- Gender classification of frontal facial images
- Deep neural networks for speech recognition
- Predicting mortality in the ICU
- Human action tagging
- Art Genre classification
- Soccer tracking
- Image manipulation using patch transforms
- Audio classification
- Foreground detection using adaptive mixture models

520-612 14

CMU Projects from previous years: 2012

- Skin surface input interfaces
 - Chris Harrison
- Visual feedback for needle steering system
- Clothing recognition and search
- Time of flight countertop
 - Chris Harrison
- Non-intrusive load monitoring using an EMF sensor
 - Mario Berges
- Blind sidewalk detection
- Detecting abnormal ECG rhythms
- Shot boundary detection (in video)
- Stacked autoencoders for audio reconstruction
 - Rita Singh
- Change detection using SVD for ultrasonic pipe monitoring
- Detecting Bonobo vocalizations
 - Alan Black
- Kinect gesture recognition for musical control

520-612 15

CMU Projects from previous years: 2011

- Spoken word detection using seam carving on spectrograms
 - Rita Singh
- Bioinformatics pipeline for biomarker discovery from oxidative lipidomics of radiation damage
- Automatic annotation and evaluation of solfège
- Left ventricular segmentation in MR images using a conditional random field
- Non-intrusive load monitoring
 - Mario Berges
- Velocity detection of speeding automobiles from analysis of audio recordings
- Speech and music separation using probabilistic latent component analysis and constant-Q transforms

520-612 16

Project Complexity

- Depends on what you want to do
- Complexity of the project will be considered in grading.
- Projects typically vary from cutting-edge research to reimplementations of existing techniques. Both are fine.

520-612 17

Incomplete Projects

- Be realistic about your goals.
- Incomplete projects can still get a good grade if
 - You can demonstrate that you made progress
 - You can clearly show why the project is infeasible to complete in one semester
- Remember: You will be graded by peers

520-612 18

**JOHNS HOPKINS
WHIRLING SCHOOL
OF ENGINEERING**

MLSP

Projects with other faculty

- Several project ideas routinely proposed by various
 - Jerry Prince (Medical imaging)
 - Mark Foster (Key identification)

520-612 19

MLSP

Amazon Alexa related projects

- Great and unique opportunity
 - Hopkins chosen by Amazon to be one of **ONLY** four schools in its initial Alexa Fellows cohort
- Please come talk to me if you are interested in these projects,
 - We have one PhD student - The Amazon Alexa Fellow - dedicated to mentoring these projects.
 - I am the liaison with Amazon; opportunities will exist to interface with technical staff from Amazon as well when they visit the Homewood campus
- Starting this Fall, we will have an Amazon Alexa Lab in the Wyman Park Building.
- We have 16 devices for you to work on in that Lab

- You can collaborate with researcher from both Amazon and CLSP in projects to give more skills to Alexa
 - Try new Ideas on Natural and Spoken Language understanding.

520-612 20

MLSP

Amazon Alexa related projects

- For Master Students
 - If you are interested to learn spoken language understanding and do a Master research thesis in this topic. Please come talk to me.
 - Advanced research on the field of speech processing and Natural Language Processing.
 - We have one PhD student – Amazon Alexa Fellow – dedicated to mentor these projects.
 - I am the liaison with Amazon, and have access to its technical staff who are available to interact with you on research efforts
 - I will supervise you for these projects.

520-612 21

MLSP

Reading the Brain

- We have a collection of EEG responses to specific sound stimuli.
- Multiple recordings for each person
 - Multiples sessions for each stimulus
- Detect stimuli from recordings
 - Mounya Elhilali
 - Merve Kaya

520-612 22

**JOHNS HOPKINS
WHIRLING SCHOOL
OF ENGINEERING**

MLSP

Reading the Brain

- Subject watches silent movie while listening to musical notes while paying attention to movie
 - Notes deviate from norm
 - How does the brain respond to deviations
- Also
 - Denoising body signals
 - Denoising electrode connectivity issues
- <http://journal.frontiersin.org/article/10.3389/fnhum.2014.00327/full>

520-612 23

**JOHNS HOPKINS
WHIRLING SCHOOL
OF ENGINEERING**

MLSP

More brain

- EEG data where the person is listening to two sounds
 - left and right ears listen to two different sounds
- Determine which part of the brain deals with each ear.

520-612 24

Parkinsons!!

Michael J Fox

Talk to US

520-612 25

Available Data

Colombian (PC-GITA)	German	Czech
50 PD, 50 HC	88 PD, 88 HC	20 PD, 15 HC
Sound-proof booth	--	--
Age ~ 61	Age ~ 64	Age ~ 60
Speech tasks: Vowels, pa-ta-ka, words, sentences, read text, monologue		

- Dedicated tests → We know what was said (good for automatic analysis but not for unobtrusive monitoring)
- Monologues, e.g. *What did you do yesterday?* (close to unobtrusive monitoring)

26

PD Speech: Characteristics

- Reduced loudness
- Monotonic speech
- Breathy voice
- Imprecise articulation
- Accelerated or slowed
- Stutter-like

Hypokinetic dysarthric Speech

Colombian patient
Female, Age: 75
UPDRS-III: 52

520-612 27

Additional Data

Dataset	Description
Multimoda I	Speech, gait, and hand-writing of 30 PD
Longitudinal	Speech of 26 PD recorded in different sessions across 4 years
Genetics	Speech of 3 groups of speakers: 6 PD with the mutation 7 with the mutation but not diagnosed PD 6 non-PD, non-mutation, but relatives
At-home	Speech, gait, and handwriting of 7 PD in 4 all day sessions

520-612 28

Topic identification from speech

- Talk to US

GROWTH

SOIL

SPECIES

Vegetation

29

Robot

- The idea is to have a smart phone mounted on the robot and use its available hardware to navigate (e.g. camera, accelerometer, gyro, microphone, etc). We control the robot using a nexus tablet (wifi-direct), and we record driving actions.
- We use data + driving actions to train a NN. End to End goal in order to predict driving commands (i.e. left, right in the case of constant speed).

<http://www.socsci.uci.edu/~ikrichma/ABR/>

Android phone
Motor Drivers
Ultrasonic sensor
Servo motor for extra camera
gyro (6 degrees)

520-612

**JOHNS HOPKINS
WRITING SCHOOL
OF ENGINEERING**

Audio Fingerprinting Challenge (CMU)

MLSP

- Given huge collection of multimedia recordings
- Given a snippet of a recording of an event
- Recover *all* other recordings of *exactly the same event*
 - Not *similar* events
 - Recordings may have been taken from different perspectives, different locations etc.
 - Video may not match at all
 - Matching video does not indicate identical event
 - Evidence in audio

520-612 31

**JOHNS HOPKINS
WRITING SCHOOL
OF ENGINEERING**

Layout Mapping (CMU)

MLSP



- You walk around these spaces all day, yet you are lost!
- Your phone walks with you.
- Use sensor (accelerometer, other sensors) readings to build up a *layout* of the space and label it

520-612 32

**JOHNS HOPKINS
WRITING SCHOOL
OF ENGINEERING**

Music Ideas: Roger Dannenberg Finding Chords (CMU)

MLSP



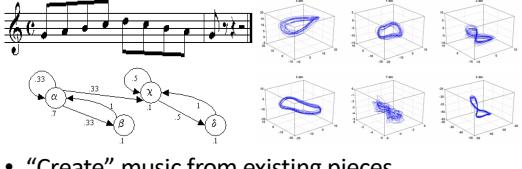
- Build a classifier to find all C-major chords in music recordings. Build a collage from the discovered sounds.

520-612 33

**JOHNS HOPKINS
WRITING SCHOOL
OF ENGINEERING**

Computational Creativity (CMU)

MLSP



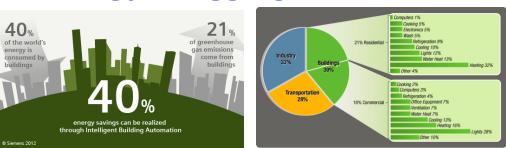
- Create music from existing pieces
 - Model ensembles of music through graphical models. *Generate* new music from the snippets
 - Model music trajectories as low-dimensional trajectories in embedding space.

520-612 34

**JOHNS HOPKINS
WRITING SCHOOL
OF ENGINEERING**

Energy disaggregation (CMU)

MLSP



- Energy disaggregation as a binary matrix factorization problem, approximated via deep nets (<http://nilmworkshop.org/2016/slides/HenningLange.pdf>)
- Based only on trajectory of current / power levels, disaggregate consumption of individual devices

520-612 35

**JOHNS HOPKINS
WRITING SCHOOL
OF ENGINEERING**

Anomaly detection (CMU)

MLSP

- Anomaly detection on whole-building energy consumption data for campus buildings
 - Data sets available
- Determine anomalous events in energy consumption
 - Can be hard to find
 - Could have serious consequences

520-612 36

**JOHNS HOPKINS
WEINBERG SCHOOL
OF ENGINEERING**

Room Occupancy Traces (CMU)

- Analysis of per-room occupancy traces (# of people in every room, every second) for an office building throughout 6 months.
- Important to optimize energy consumption

520-612 37

**JOHNS HOPKINS
WEINBERG SCHOOL
OF ENGINEERING**

Classifying sensor type (CMU)

- Classifying sensor type from just raw measurement time-series (i.e., is this the time series of temperature measurements, or is it humidity?).
- See, for example:<https://dl.acm.org/citation.cfm?doid=2821650.2821670>

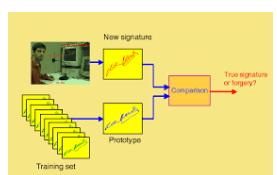
520-612 38

**JOHNS HOPKINS
WEINBERG SCHOOL
OF ENGINEERING**

Signature verification

Is this really X?





520-612 39

**JOHNS HOPKINS
WEINBERG SCHOOL
OF ENGINEERING**

Fingerprint recognition

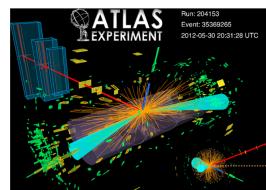



520-612 40

**JOHNS HOPKINS
WEINBERG SCHOOL
OF ENGINEERING**

Higgs Boson Machine Learning Challenge

Use the ATLAS experiment to identify the Higgs boson



22. Higgs Boson Machine Learning Challenge
<https://www.kaggle.com/c/higgs-boson/>

- Machine learning to find properties of the boson

520-612 41

**JOHNS HOPKINS
WEINBERG SCHOOL
OF ENGINEERING**

Other projects

- DNNs based on LDA or NCA (digit visualization)
- Discriminative training for generative models.
 - PLDA, Gaussian classifier for face recognition and speaker verification.

520-612 42



You get the idea

- You may pick any of these problems or come up with a fun one of your own
- They *must* exercise your MLSP skills
- Please form teams and inform me and TAs of teams no later than September 13th
 - Or we will assign you to a team
- Please send us project proposals before September 28th
 - Try to break down the steps in solving your problem in your proposal
 - Needed to evaluate feasibility
 - Example how to write a proposal
 - http://mlsp.cs.cmu.edu/courses/fall2016/project/MLSPF15_Handbook.pdf

520-612 43