Deep Learning and Digital Health

Presented by
Prof. Yu Cao, Ph.D.
Department of Computer Science
The University of Massachusetts Lowell
Lowell, MA 01854, USA
I have no actual or potential conflict of interest in relation to this program/presentation.
Basic Information about Myself (1)

• Prof. Yu Cao, Ph.D.,
  – Associate Professor (06/2016 - present), Assistant Professor (08/13-06/16) of Computer Science, UMass Lowell
  – Co-director, UMass Center for Digital Health (effective from 06/2016)
  – Assistant Professor of Computer Science at University of Tennessee (08/2010-06/2013)
  – Assistant Professor of Computer Science at California State University (07/2007-06/2010)
  – Research Fellow of Biomedical Engineering at Mayo Clinic, Rochester, Minnesota (2006-2007)
  – Ph.D. in Computer Science from Iowa State University (2002-2007)
Basic Information about Myself

• Research interests and expertise
  – Big Data Analytics
    • Scalable machine learning/deep learning algorithms and system for big data analytics
  – Computational Intelligence
    • Learning-based data stream analysis
    • Time series causality analysis
  – Multimedia Computing
    • Content-based image, video, and text retrieval and analysis
  – Biomedical Informatics
    • Digital health
Our Research Focus on Digital Health - Research Focus 1

Designing scalable pervasive healthcare monitoring, rehabilitation, and public health systems

Current Issues in Healthcare
Reactive and hospital-centered healthcare

Our Proposed Approach
Designing new scalable digital models, algorithms, and systems using ubiquitous, Internet of Things (IoT) devices and pervasive computing techniques

Outcomes and Deliverables
Technology-based, computer-aided, proactive and person-centered healthcare

Proposed Internet of Things (IoT) devices, pervasive and ubiquitous computing
Our Research Focus on Digital Health - Research Focus 2

Building high performance networking and computing infrastructure for health data transmission and computation

**Current Issues in Healthcare**

Ever growing health data and unreliable, unsecure networking

**Our Proposed Approach**

Building high performance, secure networking and computing system using Software Defined Network (SDN), fog and cloud computing, and heterogeneous computing architectures

**Outcomes and Deliverables**

Reliable and secure networking and computing system for health data sharing and computation with privacy preserving

Proposed high performance, secure, networking and computing infrastructure
Our Research Focus on Digital Health - Research Focus 3

Developing novel algorithms and systems for big data analytics in healthcare

Current Issues in Healthcare

- Tremendous amounts healthcare data, lack of insights from healthcare data

Our Proposed Approach

- Developing novel algorithms and systems using the combination of machine learning (with an emphasize in deep learning), big data in biomedicine, and high performance computing techniques

Outcomes and Deliverables

- Analytics tools & techniques for effective and efficient knowledge discovery from healthcare data

Proposed combination of deep learning, biomedical big data, and high performance computing
Our recent results in the field of deep learning with applications to digital health

• (1) Medical imaging informatics for large-scale mining/classification

• (2) Biomedical sensor informatics for scalable behavioral activity profiling
Medical imaging informatics - Sample project 1

• Project name: Improving Tuberculosis Diagnostics using Deep Learning and Mobile Health Technologies among Resource-poor and Marginalized Communities
Tuberculosis (TB)

- A chronic and infectious disease
- Affects the most disadvantaged populations and involves complex treatment regimes
- More than 9 million estimated new case and 1.5 million deaths every year
- Over 80% were in South-East Asia, Western Pacific and African (2013)
- Majority of the infected populations was from resource-poor and marginalized communities.
Medical imaging informatics - Sample project 2

- Project name: Imaging Biomarkers for Lung Cancer Screening
Medical imaging informatics - Sample project 3

- Project Name: Semantic Medical Image Retrieval: A search engine that can understand the medical terms
Medical imaging informatics - Sample project 4

• Improving Colonoscopy Quality through Automated Monitoring
  – A software-based system that produces objective quality related indicators through analysis of the video of a colonoscopy procedure;
  – To provide objective evidence for clinical practice
Medical imaging informatics - Sample project 5

- Animal Motion Capturing, Uploading, Analyzing, and Tracking Software for Biological Science
  - A **fully automated visual tracking software**
  - Has been used by a few leading biological labs (California Institute of Technology, University of Groningen (Netherlands))
Medical imaging informatics - Sample project 6

• Xbox 360 and Kinect-based motion sensing for in-home rehabilitation
Biomedical sensor informatics - Sample project 1

- Project Name: Pervasive fall detection for stroke mitigation

Aim 1: Fall Detection
Aim 2: Fall Prediction
Aim 3: Long-term Monitoring
Aim 4: Dynamic Mobile Cloud Computing
Biomedical sensor informatics - Sample project 2

- Project name: Wearable device-based Multimedia Computing Platform for Computer-aided Dietary Monitoring

**Smart watch or Smart Glass**

**Data Capturing and Transmission Software**
1. One Tap to Start Video Recording
2. Taking Food Video from Different Angles
3. Recording Dietary Context Information If Possible
4. One Tap to Stop Video Recording

**Bluetooth Connections**

**Smartphone**

**Data Transmission Software**
1. Receiving Multimedia Food Data
2. Uploading the Data to Server at Cloud

**Server at Cloud**

**Data Storage and Analysis Software**
1. Storing the Multimedia Food Data
2. Organizing and Representing the Food Data into Multimedia Food Journal
3. Analyzing the Multimedia Food Journal to Derive Dietary Information

**Multimedia Food Data**
Acknowledgment

- National Science Foundation
- National Institute of Health (RIMI Program)
- Mayo Clinic, Rochester, MN
- Harvard Medical School, Cambridge, MA
- University of Massachusetts Lowell, Lowell, MA