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New Mexico Research Spotlight Forum

1/29/2019 Artificial Intelligence & Machine Learning

Falls Risk Classification Using Smartphone Based Inertial Sensors and Deep Learning

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Capability Overview

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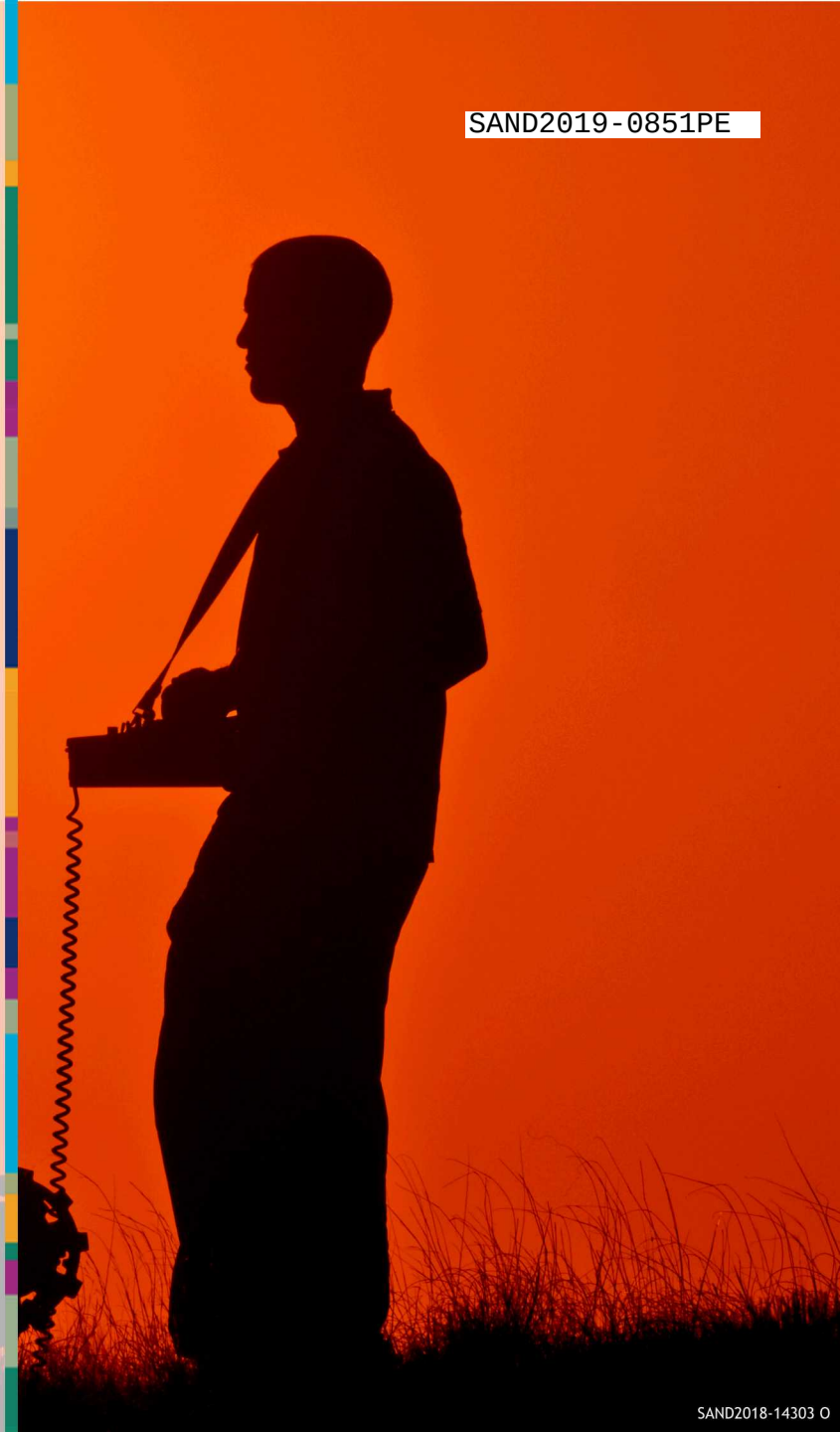

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ABOUT US

Phillip De Leon

- Professor, Electrical & Computer Eng and Associate Dean of Research
- Time-frequency signal analysis, Speech processing, Machine Learning

Keywords:

Time-frequency signal analysis, empirical mode decomposition(EMD), falls risk prediction, speaker verification (anti-spoofing)

Matthew Martinez

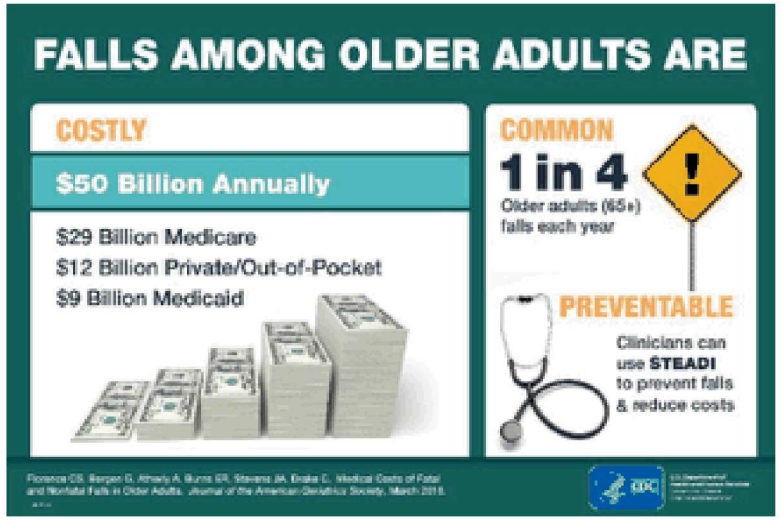
- Statistical Sciences (9136)

Keywords:

Digital Signal Processing, Deep Learning and Machine Learning for Time Series Analysis, Uncertainty Analysis, Monte Carlo Simulation

FALLS PREVENTION / FALLS RISK RESEARCH BACKGROUND

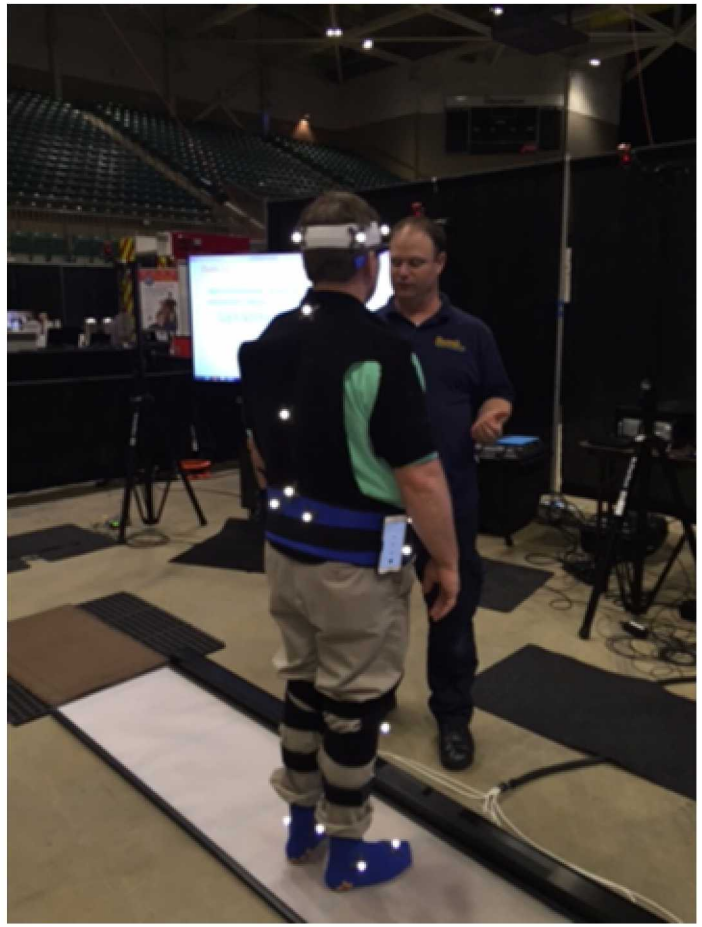
- Each year 2.8 million adults are treated for fall related injuries
  - Broken bones, hip fractures, traumatic brain injury
  - Results in 800,000 hospitalization each year
- Falls Prevention Research
  - Research has focused on assessment, prevention, and rehabilitation
  - Qualitative- and mobility-based assessments
  - Prior research has shown certain gait factors indicate elevated risk of falling
- Sensors for Gait Analysis
  - 3-D motion capture, Pressure sensitive walkways, inertial sensors
  - Inertial Sensors allow for continuous gait monitoring



Our research seeks to use smartphone-based inertial measurements and deep learning to classify older adults as either low or high falls risk

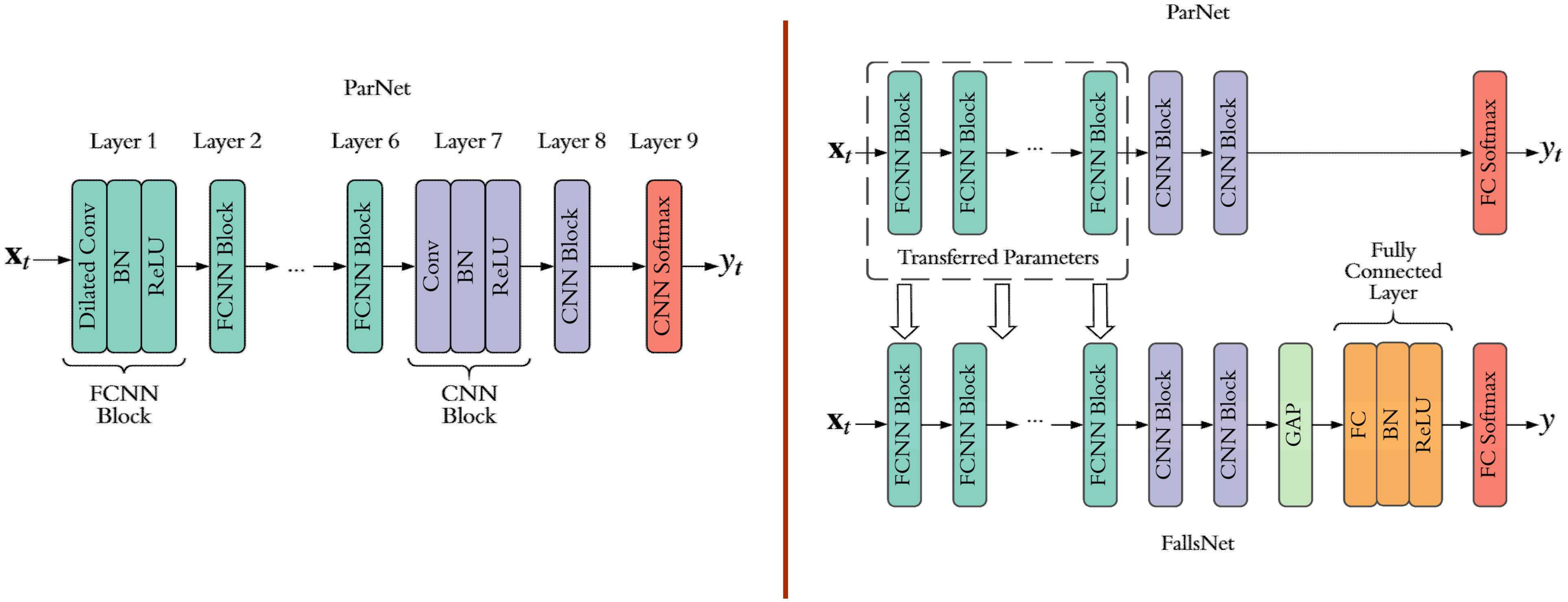
DATA SETS, LABELING, AND TRANSFER LEARNING

- Parallel data sets (IMU+Walkway)
  - Data collected in partnership with the Electronic Caregiver Company
  - Inertial data (3-axis acceleration and 3-axis gyroscope) collected with (2) Apple iPhone 6 smartphones using custom data logger app
  - Biomechanical data collected from pressure sensitive walkway
  - Data collected 256 participants age 65+
- We used biomechanical measurements from walkway data to label IMU data as low risk/high falls risk based
- Dataset is too small for adequate training of DNN
  - Train DNN for Pedestrian Activity Recognition task using HASC-PAC2016
  - Apply transfer learning to ParNet to adapt for falls risk classification task FallsNet



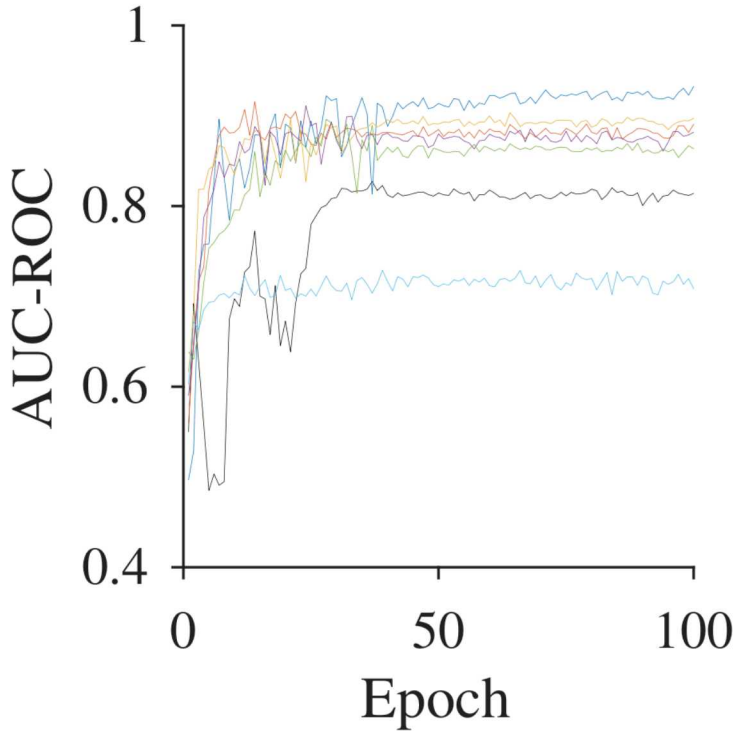
[1] J. Verghese, R. Holtzer, R. B. Lipton, and C. Wang, "Quantitative gait markers and incident fall risk in older adults," *J. Gerontol. A Biol. Sci. Med. Sci.*, vol. 64A, no. 8, pp. 896–901, Aug. 2009.
[2] M. Martinez, P. L. De Leon, and D. Keeley, "Bayesian Classification of Falls Risk", *Gait & Posture*, vol. 67, pp. 99-103, Jan. 2019.

DEEP NEURAL NETWORK ARCHITECTURE FOR FALLS RISK PREDICTION



[3] M. Martinez and P. L. De Leon, "Falls Risk Classification of Older Adults Using Deep Neural Networks and Transfer Learning," in review *IEEE J. Biomed. Health Inform.*, Jan. 2019.

RESULTS WITH TRANSFER LEARNING



Model	Layers Transferred, l, to FallsNet					
	1	2	3	4	5	6
ParNet(All, Accel)	92.1	89.7	90.4	89.7	87.0	**81.3**
ParNet(All, Accel + Gyro)	92.1	91.7	91.5	90.1	87.9	71.9
ParNet(Waist, Accel)	91.3	91.2	**92.1**	88.8	**89.7**	79.2
ParNet(Waist, Accel + Gyro)	**93.3**	**91.5**	90.3	**91.1**	86.9	73.5

[3] M. Martinez and P. L. De Leon, "Falls Risk Classification of Older Adults Using Deep Neural Networks and Transfer Learning," in review *IEEE J. Biomed. Health Inform.*, Jan. 2019.

CONCLUSIONS

- Proposed a method for classifying older adults at either low or high falls risk using inertial gait data acquired from a smartphone
- Show how to pre-train a deep neural network to learn feature representation related to human motion using publicly available pedestrian activity data
- Showed how to use a pre-trained deep neural network as feature extractor for falls risk classification
- End-to-end training of a deep neural network for falls risk classification from inertial measurements of gait

Model	ACC (%)	SENS (%)	SPEC (%)
FallsNet (Accel + Gyro)	**86.4**	**85.1**	**87.1**
FallsNet (Accel)	**82.6**	**83.0**	**82.4**
Logistic Regression	58.1	56.6	59.0
Random Forests	63.8	43.9	74.8
SVM	59.6	53.9	62.8

[3] M. Martinez and P. L. De Leon, "Falls Risk Classification of Older Adults Using Deep Neural Networks and Transfer Learning," in review *IEEE J. Biomed. Health Inform.*, Jan. 2019.

FUNDING SOURCES

Sandia National Laboratories, "Summer Faculty Research in Signal Processing and Machine Learning," 2016-2019

Sandia National Laboratories, "Instantaneous Spectral Analysis for Identification and Classification of Bursty Data in Congested Frequency Bands," 2017-2019

Electronic CareGiver, "NMSU 3D Motion Capture System for Biomechanical Data Collection," 2018

Sandia University Part Time

RESEARCH NEEDS

Vector time series classification (in this work we use 6 channels of data)

ML applications seeking high-resolution signal features (time and frequency)

New approaches for unsupervised and semi-supervised ML

Applications needing signal/source separation