Vital Extraction from Microvascular Videos

Emma Erickson[1], Dr. Robert Edman[2], Hernando Gomez[3], Micheal Pinsky[3], Dr. Artur Dubrawski[2]

[1]University of Illinois at Urbana-Champaign Department of Electrical and Computer Engineering
[2]Carnegie Mellon University Robotics Institute
[3]University of Pittsburgh Department of Critical Care Medicine

1. Introduction

Background

Microvascular videos are a method of monitoring patients undergoing surgery. These videos display red blood cell movement in the capillary bed beneath the tongue, analysis of which may indicate patient status and predict negative outcomes.

Motivation

Medical professionals rely on many vitals to understand patient status and anticipate outcomes for proper treatment. A single visual source of data would be less invasive and require fewer sensors. Our goal is to predict vital signals from optical videos.

2. Methods

Data

52 microvascular videos and accompanying vital waveforms (10 waveforms collected directly, another 14 calculated beat-to-beat) are used from a critical care experiment in which hemorrhage was induced in 16 healthy anesthetized pigs.

Data was featurized as

- Motion features extracted using 3d convolutions of the videos with filters
- Pixel intensity obtained from the average pixel intensity per frame
- Pixel intensity frequencies, the discrete Fourier transform of the pixel intensity, filtered over specific regions (i.e. HR - [0.5,5] Hz)

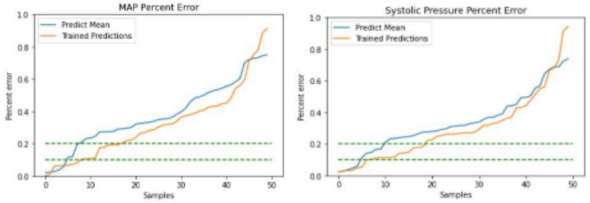
Experiments

A random forest regressor is implemented using scikit-learn for each featurization and vital. Each forest contains 100 trees with no limit on depth and experiments are run using 5-fold cross validation. Results are evaluated using R^2 to determine the extent that variance can be explained, and percent errors of predictions are also visualized.

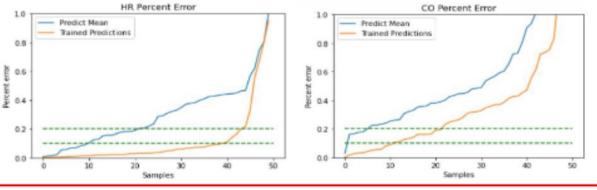
3. Results

Vital Sign	Motion Feature R^2	Pixel Intensity R^2	Frequency R^2
ART	0.136	-0.015	-0.376
ECG	-0.039	-0.714	-1.091
CCO	0.160	-0.014	-0.325
CVP	0.100	0.048	-0.690
PAP	-0.276	-0.690	-0.348
Pleth	-1478	-1216	-1706
SvO2	0.192	0.034	-0.592
SpO2	-371.7	-383.1	-469.9
MAP	0.114	-0.022	-0.374
Sys	0.076	0.012	-0.459
Dia	0.126	-0.126	-0.298
PP	-0.230	-0.147	-0.476
HR	-0.020	-0.507	0.568
SV	-0.020	-0.416	-0.530
CO	-0.093	-0.673	0.406
HRV	-1.729	-2.502	-4.968
SPV	-0.806	-1.726	-0.450
SVV	-0.771	-1.171	-0.879
PPV	-0.582	-1.157	-1.012
PPV/SVV	-0.980	-1.421	-0.277

Motion Features



Pixel Intensity Frequencies



4. Discussion

Motion features were able to predict blood pressure related vitals with R^2 between 0.1-.02. Blood pressure is an invasively monitored vital.

Pixel intensity alone was not useful in predicting information about vital signs.

Pixel intensity frequencies filtered to the range of reasonable heart rates were 80% of the time able to predict heart rate within 10% and had an R^2 value of 0.41 for cardiac output.

5. Future Work

Possible next steps include

- Apply these strategies to dataset of echocardiagrams and paired vitals
- Predict patient outcomes rather than vital signs

6. Acknowledgment

This material is based upon work supported by the National Science Foundation under Grant No. 1659774, as well as by a CMU Robotics Institute lab scholarship.