CNN-based Blood Pressure Digitization In Highland Guatemala Using A Cellphone Camera

Samruddhi Shreeram Kulkarni[1], Gari Clifford[2,3]

[1]School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA, [2]Department of Biomedical Engineering, Emory University & Georgia Institute of Technology, Atlanta, GA,
[3]Department of Biomedical Informatics, Emory University School of Medicine, Atlanta, GA

OVERVIEW

- Collecting Blood Pressure (BP) in resource poor locations is difficult
- Novel approach to capturing BP using a phone camera for wireless, non-intrusive monitoring of patient.
- Particularly important for pregnant women with hypertension

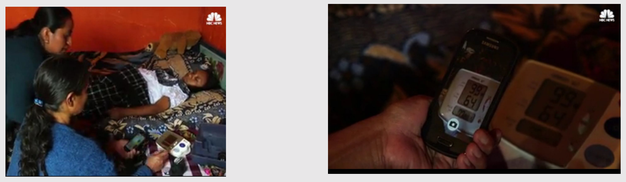

Figure 1: App to capture blood pressure readings being used by traditional birth attendants in Highland Guatemala, as featured by MSN Global Citizen. [1]

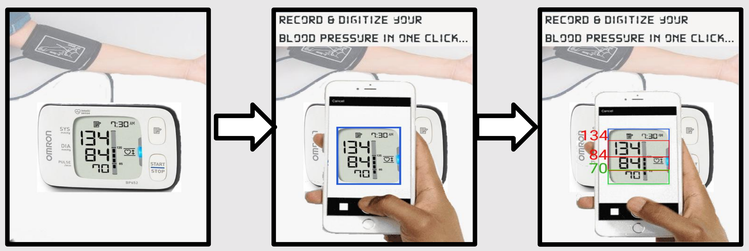

Figure 2: Steps of image transcription using cellphone camera

- 8403 images collected by traditional birth attendants of rural Guatemala, of which 1706 are labelled good quality readable by multiple over-readers[3]
- In addition to that, 10,000 augmented artificial images of single BP LCD are created with realistic noises

MATERIALS AND METHODS

Artificial Dataset Generation

10,000 artificial BP images augmented with realistic noises(rotation, crop, blur, parallax, reflections, contrast) created using blank BP monitor image with no reflections/glare and a LCD font image

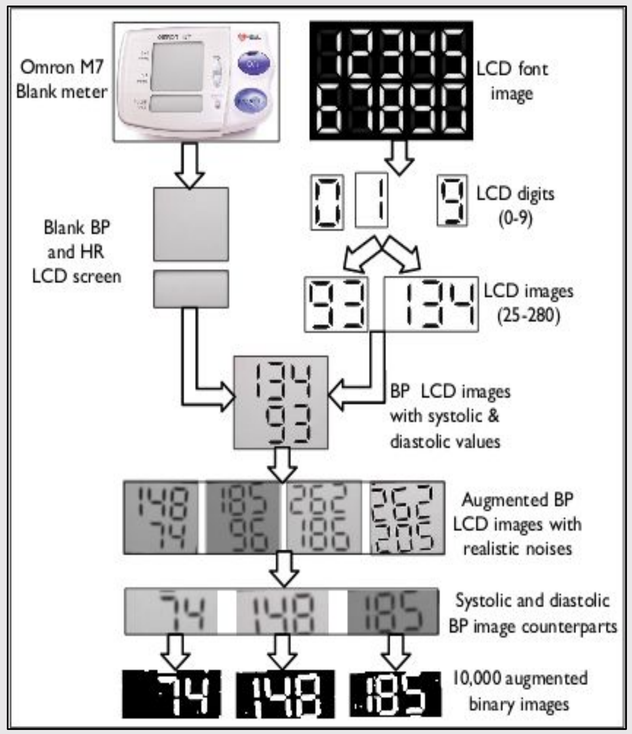

Figure 3: Steps to generate augmented artificial single LCD dataset

Generation of Single LCD images:

- Preprocess image under test and extract systolic, diastolic and heart rate LCD images by contour detection
- Corresponding single LCD binary frames fed to classification model

Image Transcription:

- A 3 layer convolutional neural network (CNN) model developed to transcribe images into numeric values
- Model simultaneously learns (i) the digits and (ii) where to look for them.[2][4]
- Each CNN layer followed by batch normalization, max pooling, dropout layers
- All digits are estimated at once using a softmax dense layer

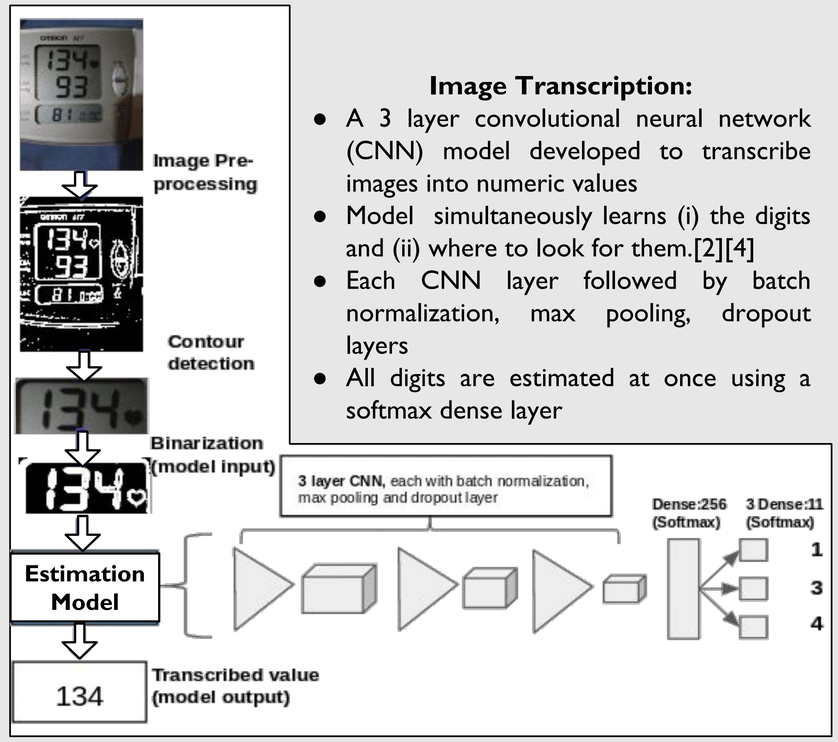

Figure 4: Transcription stepss of blood pressure meter image into numerical value

RESULTS

Performance of 2 models is measured on a held out data set of 25% of images each labelled either as "good quality" (N=428) or "bad quality" (N=1675)

TRAIN / TEST		75 % Good Quality data (N = 1278)		75% (Good quality data (N= 1278) + Bad quality (N= 5022) data)	
	For BP LCD	Classification accuracy (%)	MAE (mmHg)	Classification accuracy (%)	MAE (mmHg)
Good quality (N=428)	Systolic	88.8	2.9	91.1	3.0
	Diastolic	90.7	1.4	93.0	0.6
Bad quality (N=1675) data	Systolic	65.5	9.1	69.4	8.9
	Diastolic	69.0	6.3	73.3	2.9

CONCLUSIONS

- A scalable, non-intrusive wireless monitoring of hypertension in pregnant women is possible using the proposed approach
- Addition of bad quality Guatemala images with different noise factors help improve prediction accuracy by modelling the noisy image components
- The estimation accuracy obtained in these experiments can be further increased by improving noise removal techniques in preprocessing

FUTURE RESEARCH

Future investigation will be conducted in following areas:

- Digit-by-digit evaluation of misclassifications at each place value in number
- Study characteristics of different types of bad quality Guatemalan images
- Differentiate images based on quality

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