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Development of PPG and ECG Signal Generator to Automate System and Algorithm Validation

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Problem Statement

- Healthcare solutions like smart watches are extremely important and making significant impact on daily life of people.
- Significant amount of research has focused on developing algorithms for measuring heart rate fast and accurately.
- However, it is equally important to validate the sensors and algorithms for their functionality and performance for conformance with requirements and validation at system level requirements.
- Sensors performance is very critical for the PPG and ECG signals quality which in turn very important for the algorithms performance.

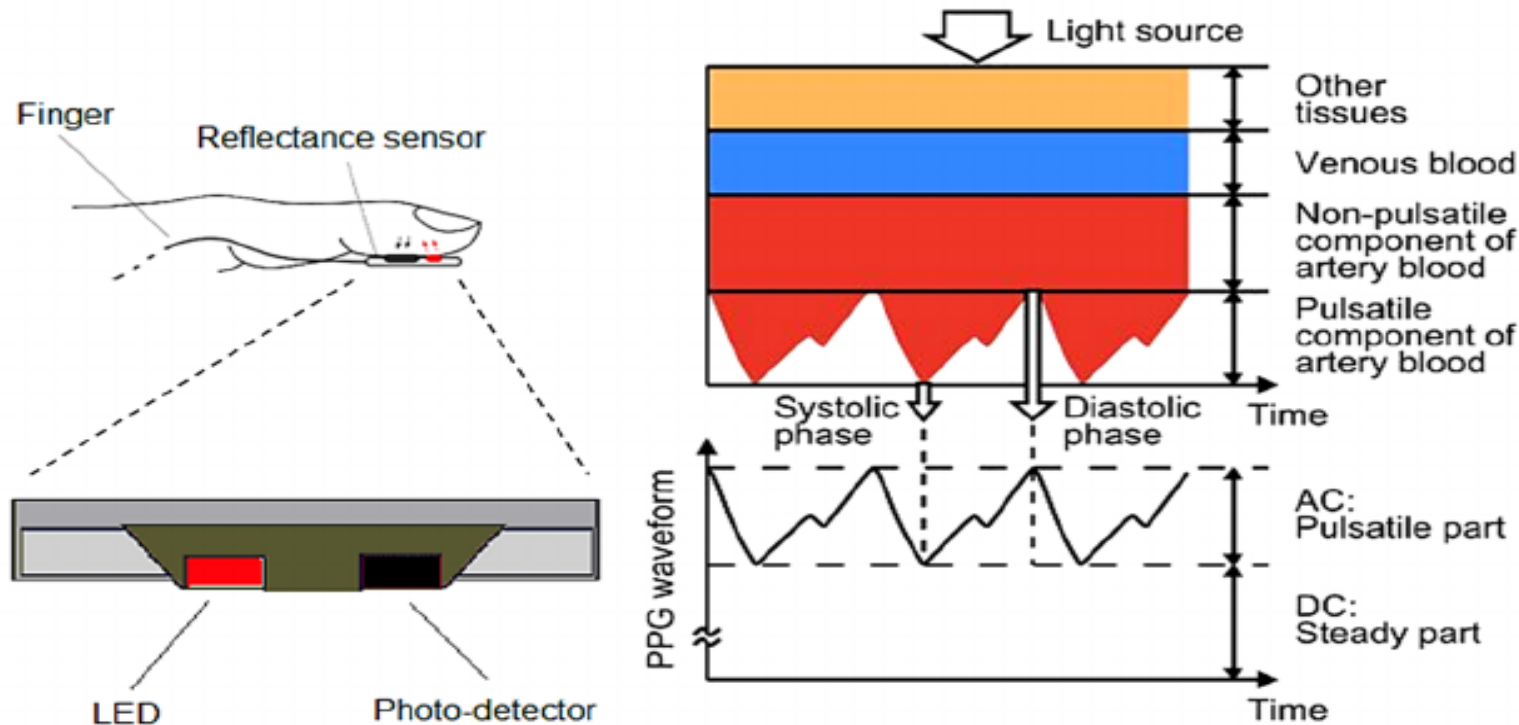


Problem Statement

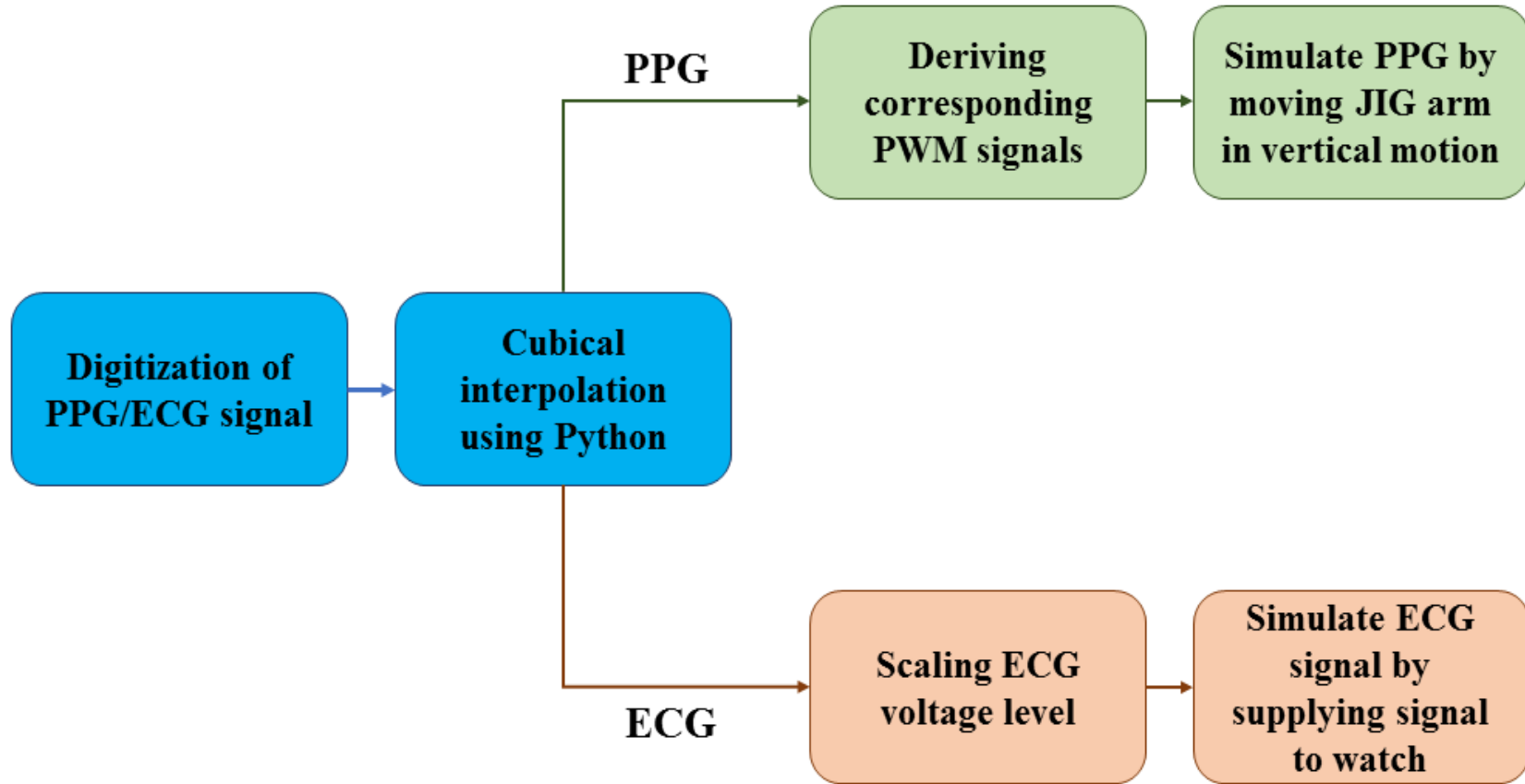
- Testing sensors and algorithms validation is key challenge for these healthcare solutions. The functional and non-functional conformance with specific requirements is also important.
- It is also useful to validate different system level use cases which are not always practical due to lack of availability of such test subject (human).
- Existing solutions available in market are as below :
 - <http://www.labtech.hu/ecg-simulators/23-products/ecg-simulator.html>
 - <http://global.flukebiomedical.com/biomedical/usen/biomedical-test/simulators-controllers/prosim-4-vital-signs-patient-simulator.htm?pid=72621>
- However, current solutions doesn't give freedom for fine resolution for testing ECG. ADI's solution for simulating ECG gives freedom for generating HR between 40-240 bpm with fine resolution of 1 bpm.

Back Ground

Electrocardiogram (ECG) deals with electrical activity of heart and Photoplethysmogram (PPG) gives measurement of pulsatile blood flow which is one of the easiest way of measuring Heart rate as shown in below figure.



Your solution approach

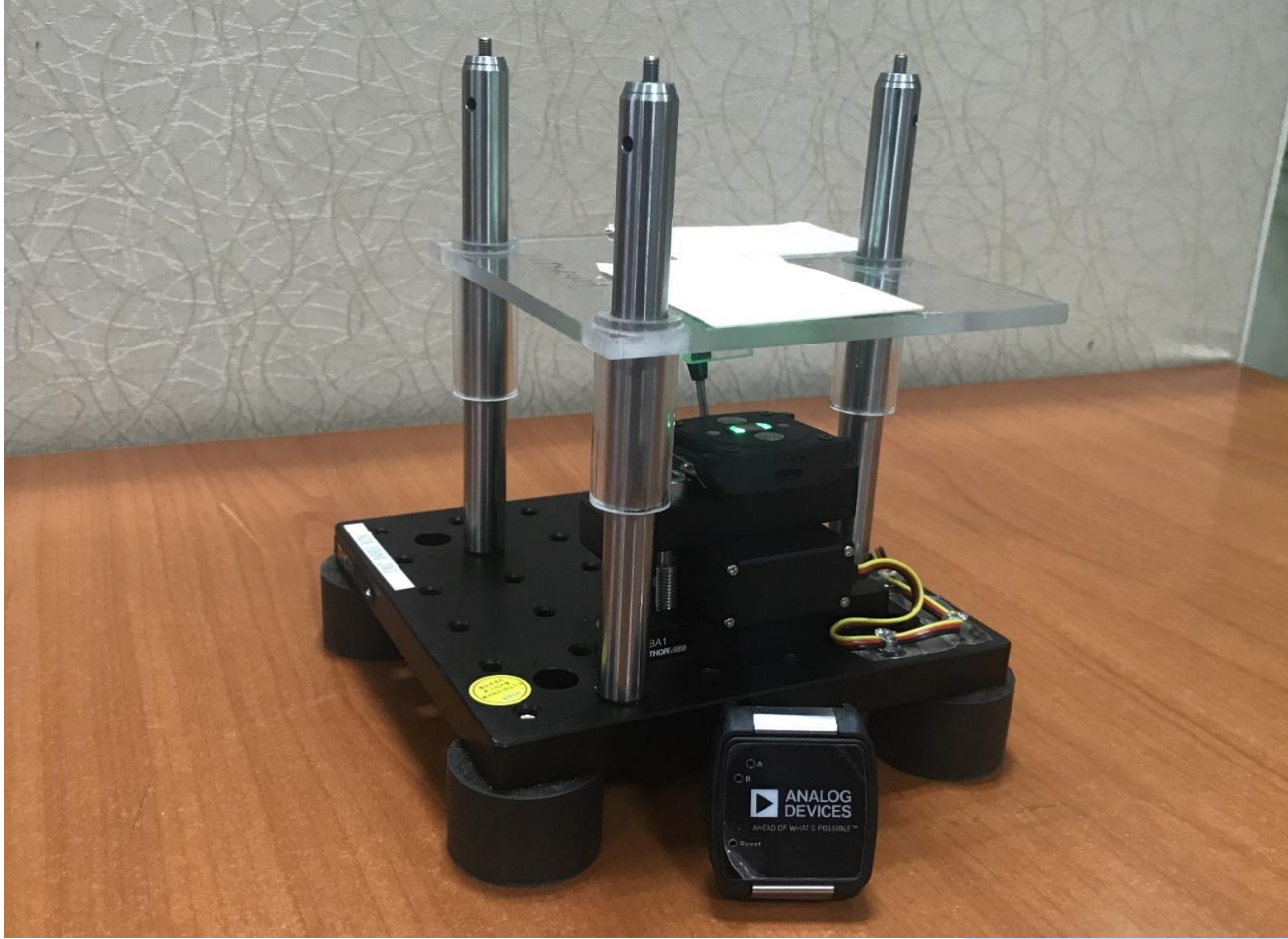


Your solution approach

- For both simulators, PPG and ECG signals were digitized and cubic interpolation was performed. For PPG simulator, PPG JIG was used and customized software converts digitized signals into PWM signal.
- Motorized JIG moves reflective surface vertically to create change in reflecting light generated by ADPD sensor. tracking and oversight.
- Similarly, ECG simulator generates constant and variable HR values. Both simulator uses various modes of operation

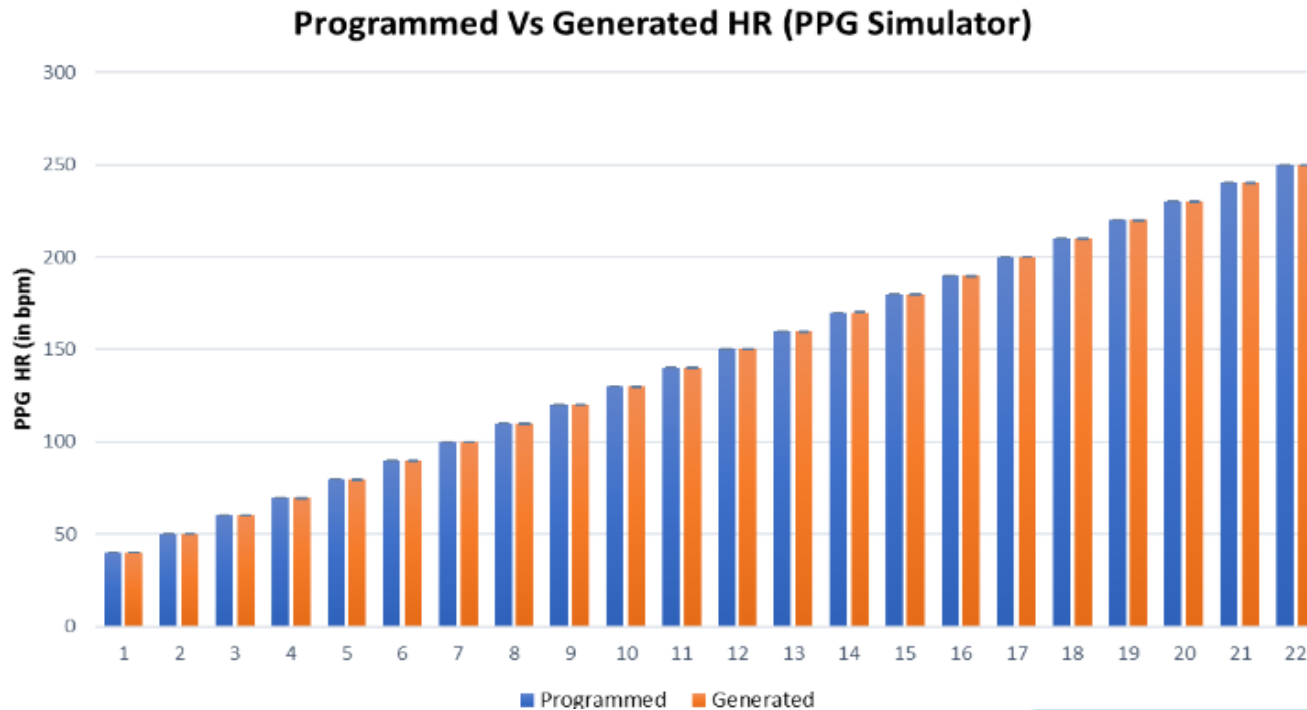


Your solution approach



Experimental Results

PPG simulators generates signal with average error **lesser than $\pm 1.5\%$** and ECG generates lesser than **$\pm 0.11\%$** from programmed values.



Comparative study

Feature	AD Simulator	Other products
ECG Signals supported	3 LEAD*	3 or 12 LEADs
Normal ECG signals	Any signal can be generated	Maximum 36 varieties
Heart rate supported	40 – 240 with resolution of 1bpm	Preprogrammed to only 4 fixed heart rates
Heart rate modes	4 Modes: Fixed, Ramp Up, Ramp Down and Random	1 Mode: Fixed
Amplitude variations	10	3
Pathological ECG signals	Any signal can be generated +	Preprogrammed to support 10 only
ST Segment variations	User configurable	Preprogrammed to support 3 only
Automation support	Yes	No
Cost	~\$20 in bulk	>\$200
Software Upgrade	Yes	No

Summary

These simulators are useful for tracking the lead time in prediction of HR value for different HR algorithms. It is easy to simulate human like situation without actual human intervention during system and product testing.

