

PIEZO FILM SENSOR FOR CAPTURE OF ARTERIAL WAVE PULSE - RESULTS*

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V) Results

The experiments conducted can be divided into three categories

1. Experiments to reduce the noise in the arterial pulse signals - 7(a) – 7(c)
2. Experiments to test different sensor configurations - 7(c) – 7(d)
3. Experiments to test the position sensitivity of the sensor. - 7(e) – 7(g)

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Figure 1

Fig 7(a): Noisy wrist arterial pulse signal when an external pressure of 120 mm Hg is applied. The peaks get inverted as the arterial pressure goes above the systolic pressure for the subject. The noise in these readings is caused when the tail of the sensor moves due to subject breathing motion. This was corrected later by taping the tail firmly in place.

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Figure 2

Fig 7(b): Wrist and mid arm readings taken from a subject when the sensor no backing is used and no external pressure is applied.

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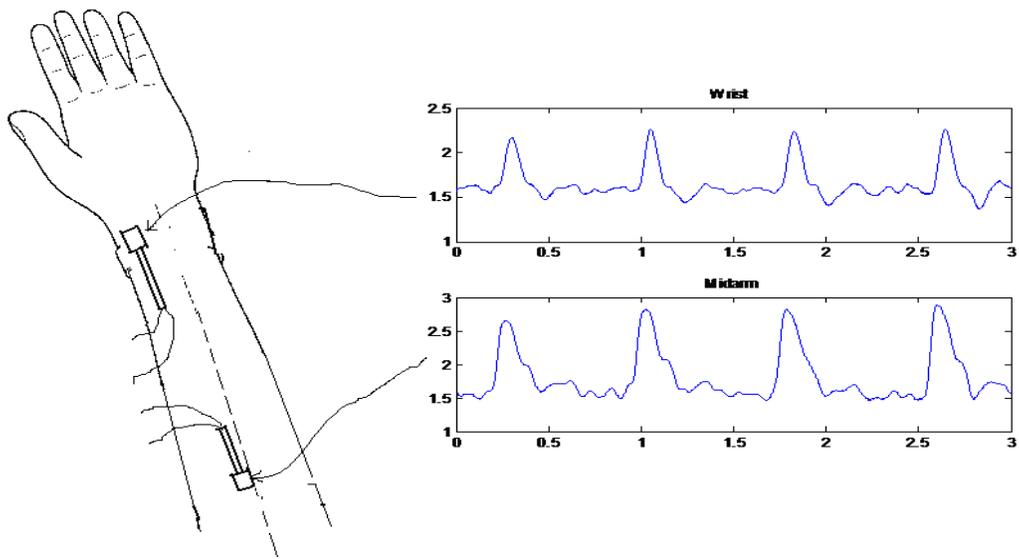


Figure 3

Fig 7(c): Wrist and mid arm readings taken from a subject when no external pressure is applied. Sensor is wrapped tightly in place using a backing.

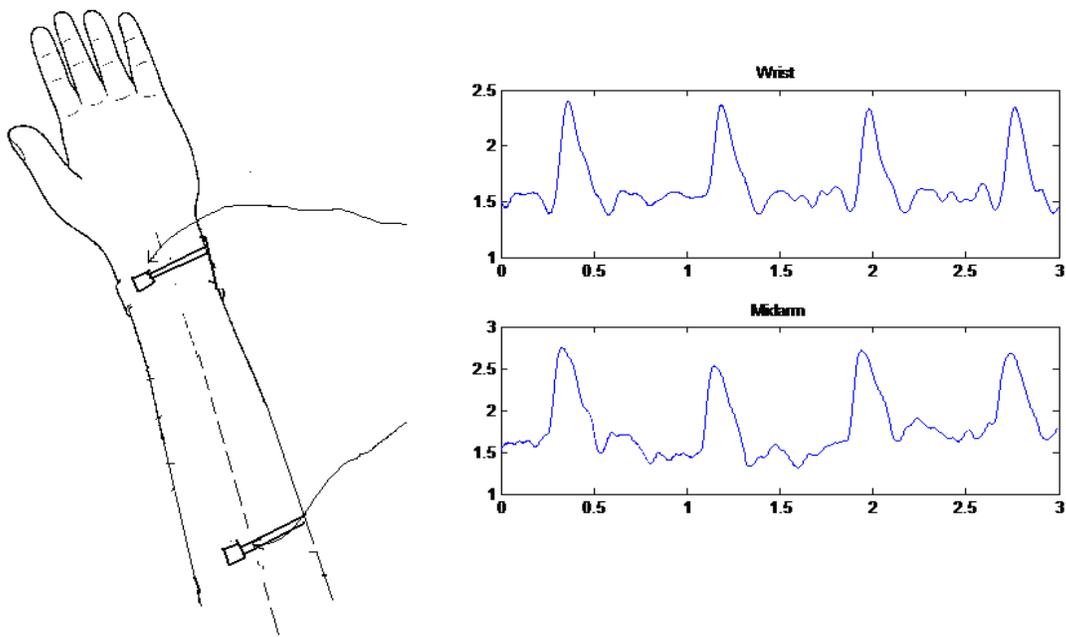


Figure 4

Fig 7(d): Wrist and mid arm readings taken from a subject when the sensor is wrapped horizontally on both the wrist and mid arm and no external pressure is applied.

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Figure 5

Fig 7(e): Wrist sensor off from the pulse location by 0.5 cm and the mid arm sensor off from the pulse location by 2 mm with no external pressure of 80 mm Hg.

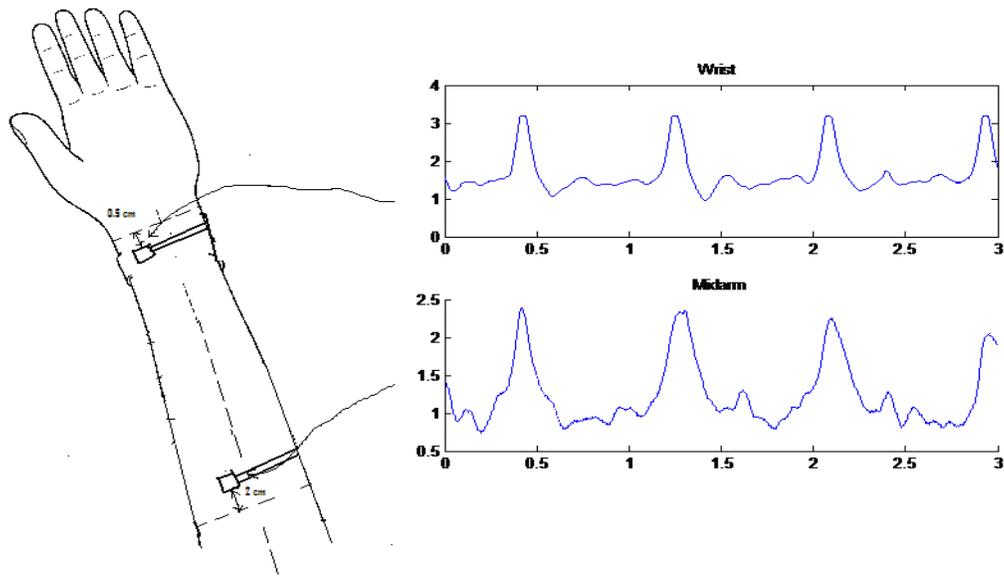


Figure 6

Fig 7(f): Wrist sensor off from the pulse location by 0.5 cm and the mid arm sensor off from the pulse location by 2 cm with an external pressure of 60 mm Hg.

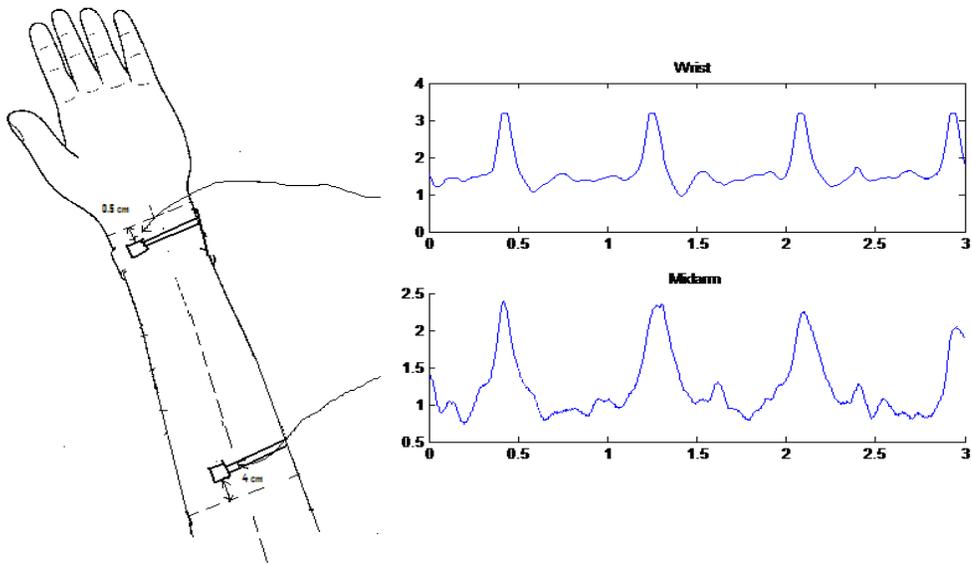


Figure 7

Fig 7(g): Wrist sensor off from the pulse location by 0.5 cm and the mid arm sensor off from the pulse location by 4 cm with an external pressure of 80 mm Hg.

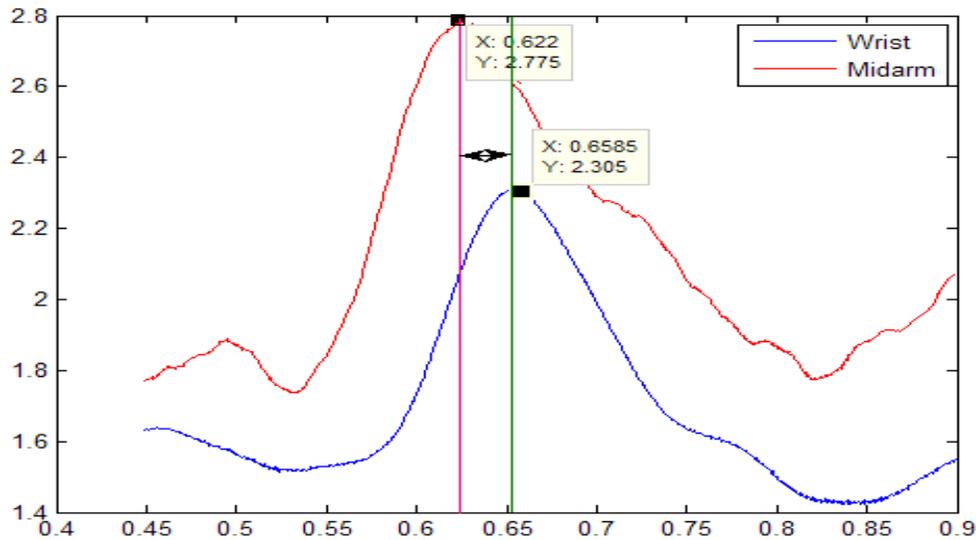


Figure 8

Fig 8: Computation of delay using the wrist and mid arm signal. The delay in this case is 0.036 sec.

VI) Discussion

Following characteristics of sensors were determined:-

1. The sensor is very sensitive to EMI. Another practical limitation stems from the fact that piezoelectric sensors require the presence of electrically conductive material (e.g., electrodes and lead wires) at the sensor location on the test subject. The system consequently cannot be used in environments where the presence of such materials would be problematic. For example, electrically conductive materials have been known to cause severe burning of patients undergoing MRI examinations, due to the presence of strong radio frequency fields generated by the MRI machine.

In our experimental conditions when the laptop was connected to the 60Hz power

Supply line a lot of noise was generated and the signal got buried in it.

1. If the electrodes complete a circuit with any of the wires touching on a conducting surface a circuit is created with resistance of almost an ohm which acts as another source of noise.
2. The person has to be perfectly stable while taking the readings. If the hand is kept hanging down a lot of noise is produced. Breathing can also produce noise.
3. The sensor is very sensitive to the location of the pulse. The sensor should be placed within 1 cm radius of the pulse location.
4. The sensor coupling to the skin should be uniform. For eg: If you press the sensor down with your fingers it is not coupled with the skin very well.
5. Arterial pulse amplitude differs from person to person depending on pulse pressure. Thus the external pressure applied to get arterial pressure waveforms will vary for each person.

VII) Future work

We propose a few future experiments which will further improve the present device.

1. Sensors with smaller electrode length can be used.
2. Laminated sensors which are wider and cover more region on the hand can be used.
3. Different pulse location like the temple or near the ear lobe can be used.
4. The gain on the mid arm pulse amplifier should be reduced by half to prevent clipping of the mid arm signal.
5. The entire setup should be taped on one hand and then the person should be allowed to move around. The arterial wave pulse should be recorded when the person is moving around.
6. This experiment concentrated on getting prominent peaks to determine the systolic blood pressure. In the next set of experiments we should concentrated on getting both prominent peaks and valleys to record systolic and diastolic blood pressure.

VIII) Conclusion

Based on the current setup we can say that one of major obstacles in implementation of this project is the presence of motion artifacts and position sensitivity of the system. In the future this will be a major concern if we are to implement an ambulatory system that can be used by the person in any condition. In the present case the sensor produces good signals when a person is in a stable state. Some of the key achievements of this experiment have been low cost of the device. The complete circuit with the sensor and amplifier filter circuit costs less than \$20. If the data analysis can be done at an external server the device price can be kept real low. Also we achieved a substantial reduction in noise due to breathing. The use of a foam backing ensured a better coupling with the skin. The backing can be used to concentrate pressure at the desired location. The velcro wrap also provides better coupling with the skin. Using the child cuff we have found that as the sensor moves away from the pulse location, applying more pressure to the sensor can give better arterial pulse. The choice of laminated sensors also serves the purpose well since it enables a stiff coupling between the skin and the sensor. The laminated sensor also prevents moisture forming on the sensor. The laminated electrodes reduce the noise. Also we found out that a lesser electrode length reduces noise. We tried a configuration with the sensor placed horizontally and the tail wrapped around the wrist. This configuration produced less noise, even when the sensor was off from the pulse location by around 1 cm. There have been significant advances in this project; however a lot of work needs to be done before the device becomes fully operational.

IX) References

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