BABY BELT : A LOW-COST UTERINE CONTRACTION AND FETAL HEART RATE MONITORING BELT

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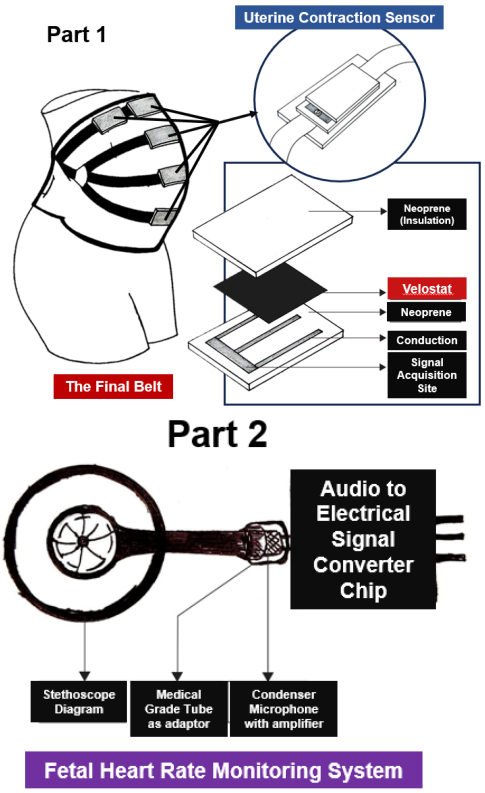
Problem Description : Uterine Contraction (UC) and fetal heart rate (FHR) are monitored as a standard assessment of fetal well-being during the last stages of pregnancy and labor. Currently, CTG machines along with Doppler Technology are commonly used for monitoring UC and FHR for pregnant mothers, but can be costly and complicated for low-income patients of third world countries like Bangladesh.

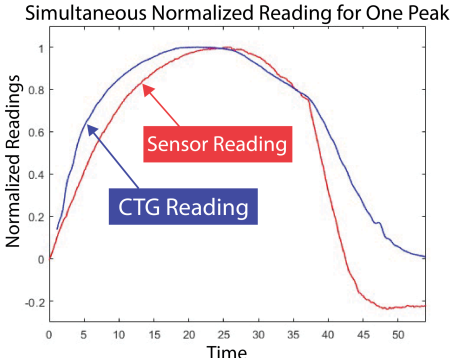
Solution Concept : For monitoring Uterine Contraction (UC) and fetal heart rate (FHR) during the last stages of pregnancy and labor, we propose a low-cost wearable pregnancy monitoring belt.

The Uterine Contraction (UC) will be measured by completely fabric-made piezoresistive sensors. The piezoresistive material used in the sensor is a low-cost Velostat sheet which changes its resistance with changing uterine contraction pressure. Fetal Heart Rate (FHR) in final stages of pregnancy will be measured using a stethoscope and condenser microphone, with a subsequent digital filtering process to extract the fetal signal from potential interference.



The belt, priced at $70, serves as an affordable alternative to the costly CTG machine (priced over $2000). The belt addresses monitoring of the last stages of pregnancy which is a crucial time for continuous standard assessments for early abnormality detection. Accessibility to CTG machine is not wide-spread in developing countries like Bangladesh. So, a low-cost alternate device can ensure more accessibility to pregnancy health monitoring.

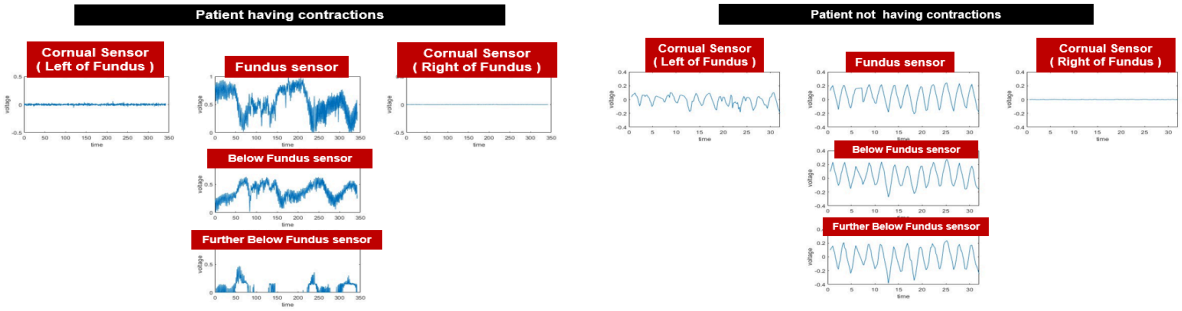
Reduction to Practice : Using an inflating ball mimicking pregnant abdomen, Velostat sensor sensitivity was compared with CTG reading on the same setup. The result showed a good correlation and the sensor also covered the range of UC intensity (0 to 99mmHg) of standard CTG machines. **Correlation numbers 0.9854 (Upcycle) , 0.8295 (Down-cycle) show high validation to CTG machines . (Video: Correlation with CTG on same pressure setup.mp4)**



For the FHR Sensor, before patient testing, a phantom was used to mimic the maternal abdominal layer and detect adult heart rates from top of it.

(Video : FHR system - Phantom Testing.mp4)

We tested the final belt on a few voluntary patients in the maternity ward, and it showed almost expected results.



For patients having contractions *(Top Left Image)*, the fundus sensor shows the pattern of contraction similar to the CTG machine. The sensors exactly below the fundus also pick up the contraction signals after time delay and decreasing strength showing propagation of the contraction wave. Hence the spatial contraction can be measured with this device as planned. However, the Cornual sensors do not give significant data and might have to be revised. ***(Video : Patient having Contractions.mp4).***

For patients not having contractions *(Top Right Image)*, the regular pattern of breathing is picked up by the sensors proving their sensitivity. ***(Video : Patient with No Contractions.mp4)***

For the FHR Sensor, Upon testing on a voluntary patient, the fetal heartbeats were recognizable but contaminated with other noises. ***(Video : FHR System - Patient Testing.mp4).*** The solution we want to employ for this is: Independent Component Analysis (ICA) of the signal extracted from our digital stethoscope which should lead to four simultaneously acquired components: maternal ECG noise, fetal ECG noise, maternal breathing movement noise and denoised Fetal Heart Sound signal. The denoised Fetal Heart Sound signal is our target signal.

Pathway to Implementation : We are currently working in collaboration with the Department of Biomedical Engineering, BUET while collecting data to fine tune our belt from a number of hospitals including Monno Medical College and Hospital. After making our device ready for market, we plan to reach customers through a subscription model. We will work directly with physicians and health workers who will select mothers needing monitoring. The belt will be rented for three months (the last trimester). The subscription fee will be flat 25$ for these whole 3 months. In a laboratory setting, the belt takes 38$ to make. So, after 2 subscriptions, we recoup the cost of production. Each belt can be ideally rented out 3 times a year. 265,000 mothers face fetal distress every year in Bangladesh. At the full potential production of our belts, this is the market size we can reach as Bangladesh lacks Cardiotocography machines which are needed to diagnose severity of fetal distress pretty easily. Working with an established industrial partner, we can reach a gross profit of 50,000$ easily even if we access less than a percent of the potential market. This

belt is a crying need for developing countries where expensive instruments like CTG cannot be set up. Unfortunately, developing countries are the ones reporting more cases of fetal distress. As we fully function as a complete low cost alternative to CTG, we are ready to meet this enormous health challenge.