1 PROPOSAL: Distributed Triangulization Method for Impact Source Localization Using Newton Raphson

The long term goal of my project to build a distributed network of PZT sensors whose cards can localize an impact in a composite board based on a method called Sparse Reconstruction. Figure 2 describes the physical setup of the PZT sensors.

For the puposes of this course, I will use the triangulization method described in [1] in a distributed grid of sensors in order to localize the source of an impact through consensus. This means that each sensor will compute the Newton Raphson optimization along with other numerical optimization methods such as the Conjugate Gradient Algorithm. I will also compare the results for the methods used with the aspects treated during the semester (e.g. work precision diagram, order of accuracy, etc.)

$$
\begin{aligned}
E(x_0,y_0) = & \left(\left\{ \frac{\sqrt{(x_1-x_0)^2+(y_1-y_0)^2}-\sqrt{(x_2-x_0)^2+(y_2-y_0)^2}}{\sqrt{(x_2-x_0)^2+(y_2-y_0)^2}-\sqrt{(x_3-x_0)^2+(y_3-y_0)^2}} \right\} - \frac{t_{12}}{t_{23}} \right)^2 \\
& + \left(\left\{ \frac{\sqrt{(x_2-x_0)^2+(y_2-y_0)^2}-\sqrt{(x_3-x_0)^2+(y_3-y_0)^2}}{\sqrt{(x_3-x_0)^2+(y_3-y_0)^2}-\sqrt{(x_1-x_0)^2+(y_1-y_0)^2}} \right\} - \frac{t_{23}}{t_{31}} \right)^2 \\
& + \left(\left\{ \frac{\sqrt{(x_3-x_0)^2+(y_3-y_0)^2}-\sqrt{(x_1-x_0)^2+(y_1-y_0)^2}}{\sqrt{(x_1-x_0)^2+(y_1-y_0)^2}-\sqrt{(x_2-x_0)^2+(y_2-y_0)^2}} \right\} - \frac{t_{31}}{t_{12}} \right)^2
\end{aligned} \tag{12}
$$

Figure 1: Equation taken from [1] describing the optimization to be done based on data

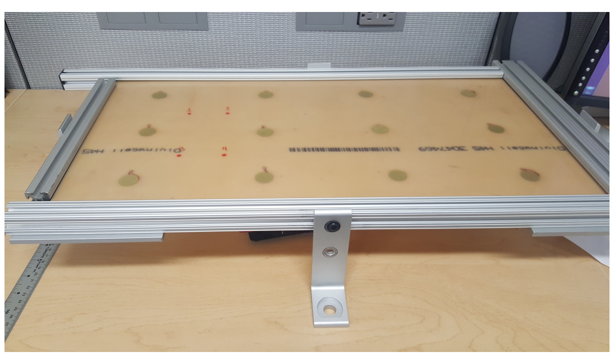

Figure 2: Physical setup of the sensors. It is a composite board with a grid of PZT sensors where each one is connected to a Particle Photon.

It is important to mention that the piezo-sensors can only measure the shear waves that occur during the impact/touch because the voltage comes from having the piezos get "squished." Another consideration to take into account is that solving time is a very important variable since we would like to obtain near-real-time results. Finally, a source position estimate $\hat{\mathbf{r}}^{(j)}(0) = [\hat{x}_{sk}, \hat{y}_{sk}, \hat{z}_{sk}]^T$ is what I intend to determine after the solution of the elastic wave equation. In Figure 2, the dots drawn with sharpies indicates the positions that I will be testing.

Here is my detailed plan of attack:

- Extract important measurements from data
- Try then to solve for the inverse problem using the methods described in the [1]
- Produce animation of the impact localization
- If I have enough time left, I will try to solve the elastic wave equation in a forward manner using Finite Volume Methods.

  All my files for the project will be in 'source$_{l}ocal - board'inmygithub.$

References

[1] Tribikram Kundu. Acoustic source localization. *Ultrasonics*, 54(1):25 – 38, 2014.