Classification of Material by Measuring Fluid-Flow Obstruction

Submitted by,
Shobith Thomas Jacob
Jazil Nazir
Shemeena P. Abdulrazaq

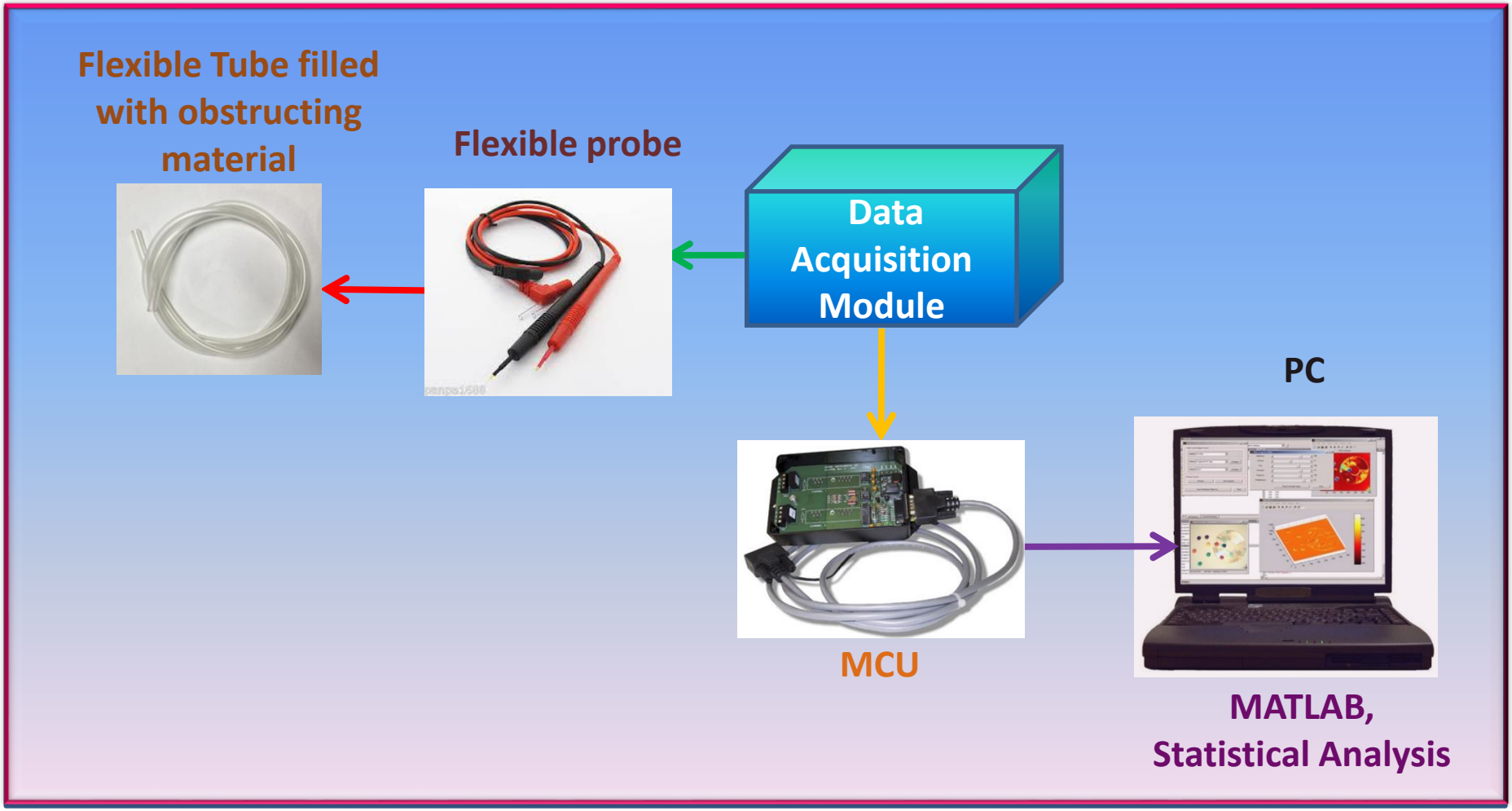
Problem Statement

- Characterization of obstructing materials in a free-flow fluid path in human body using passive data acquisition method in **100% risk- free** manner at **low cost**
  - Exact procedures for removal of material can be determined only if the nature of the material is known
- Active methods are costly and the risk of external matter in the cavity needs to be mitigated
- Experiments were non-repeatable in real-time scenario

Approach to Problem (Contd…)

- SFO created a lab set-up which could emulate the actual scenario
- A device was created utilizing SFO's in-house mechanical expertise in 3D printing
- The device had a compartment to keep obstructing material of various hardness
- A passive sensor was used in conjunction with a high resolution, high accuracy ADC to capture the signal from the material
- SFO developed a custom software to record and display the data in real-time

Approach to Problem (Contd…)



Approach to Problem (Contd…)

- SFO found that the background noise significantly corrupts the signal
- Savitksy-Golay (SG) Filter with appropriate filter coefficients cleans up the signals
- To find out the first impact point, a two-pronged strategy was adopted
  - Finding out the approximate point of impact using SG filter with a specific set of parameters
  - Pin-pointing the exact location by working around a small area near the approximate point

Approach to Problem (Contd…)

- The SFO algorithm worked in a completely autonomous manner
  - Iterates itself over the whole length of the signal period
  - Ignores the effect of noise significantly
  - Adapts the filter coefficients (all by itself) to extract the exact point of impact

Approach to Problem (Contd…)

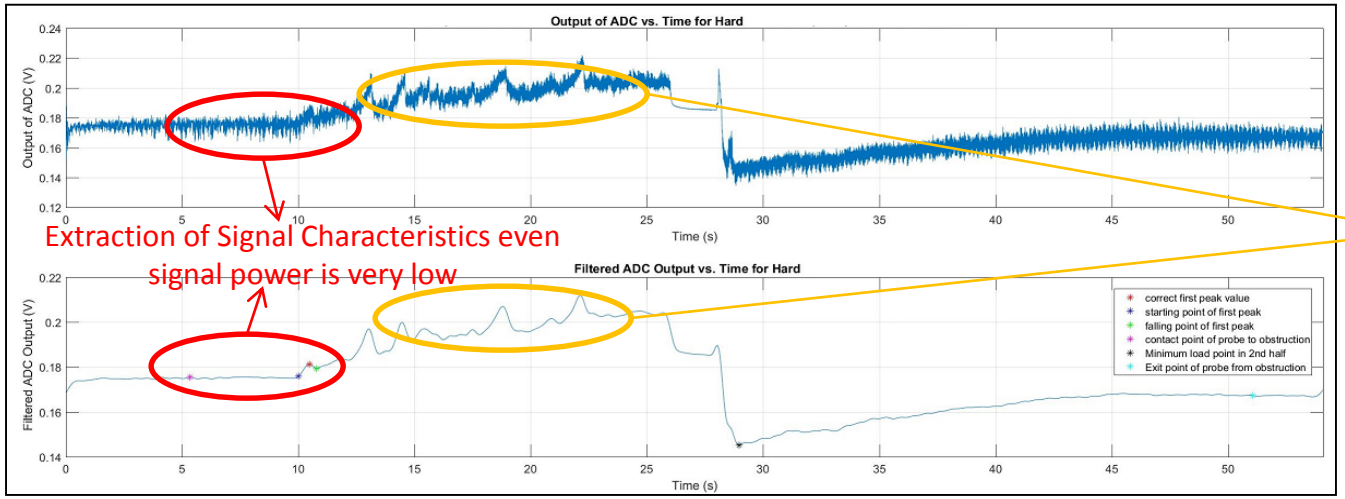
- Parameters varied significantly between experiments even when the same impact material was used
- SFO used statistical analysis of the parameters to classify the nature of materials

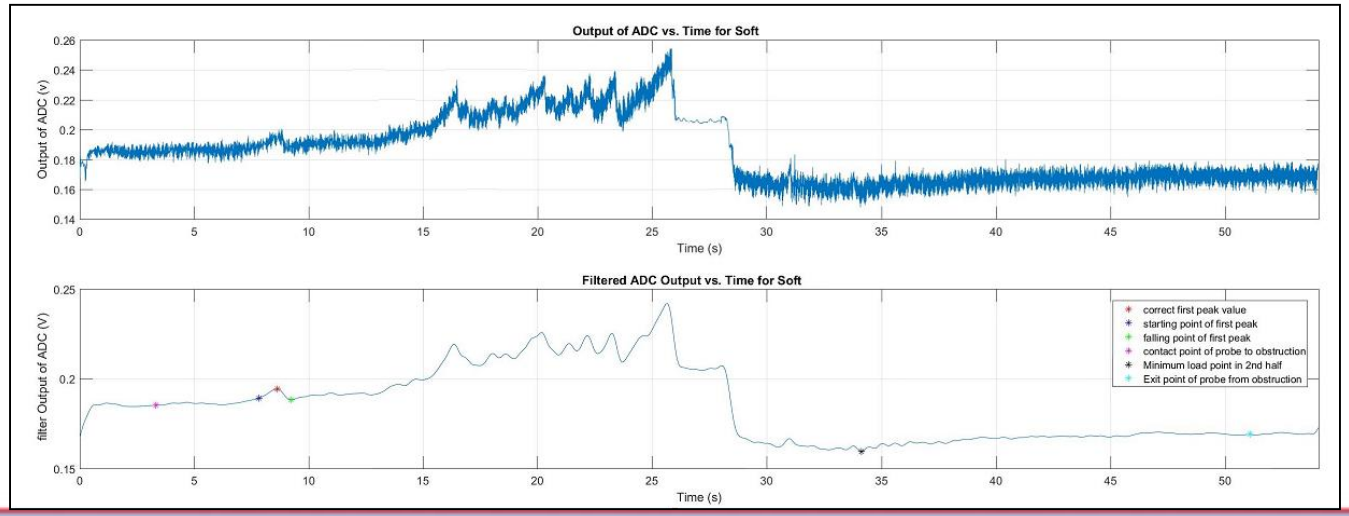
Tools Used

- MATLAB R2016a
  - DSP System Toolbox
  - Signal Processing Toolbox
  - Wavelet Toolbox
- Minitab 17.2.1

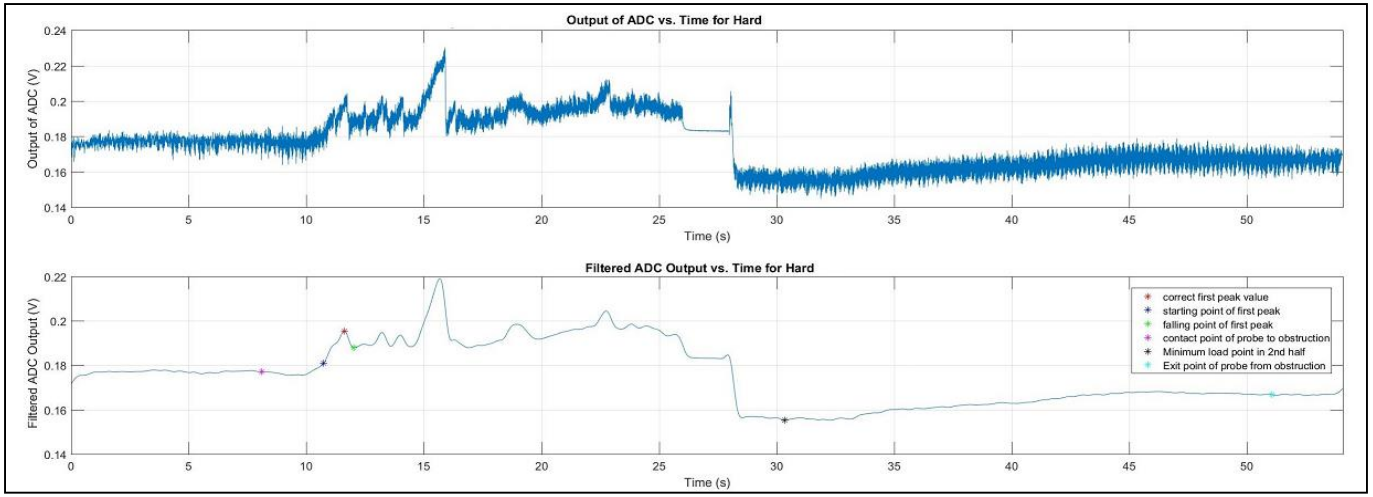
Results Achieved

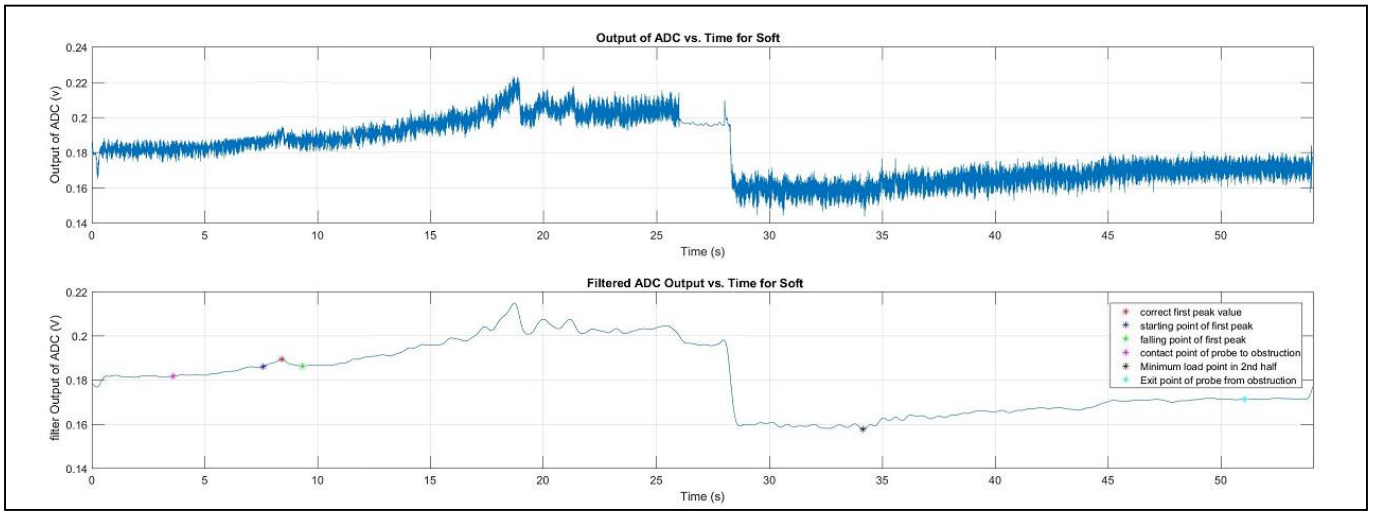
- Clean-up of signal and identification major characteristics



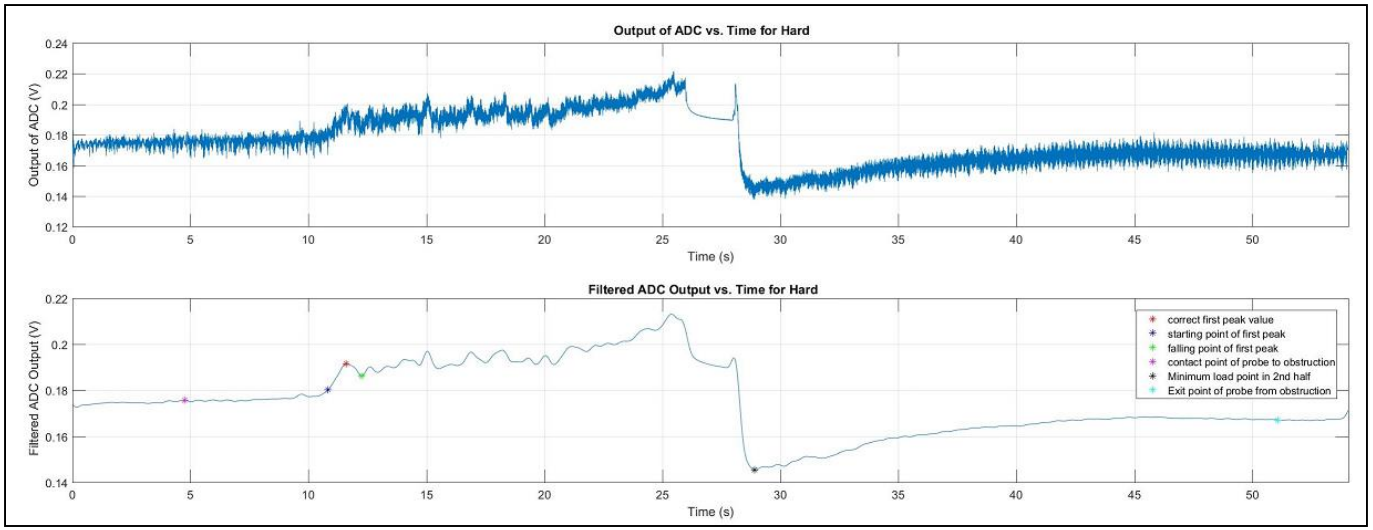


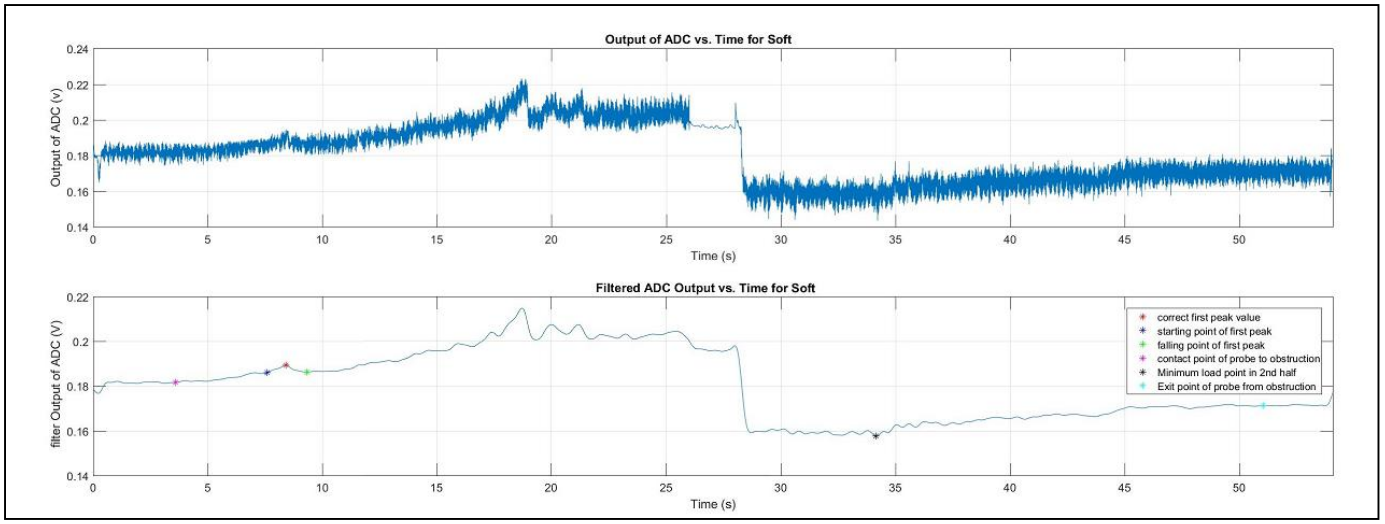
Results Achieved (Contd…)





Results Achieved (Contd…)

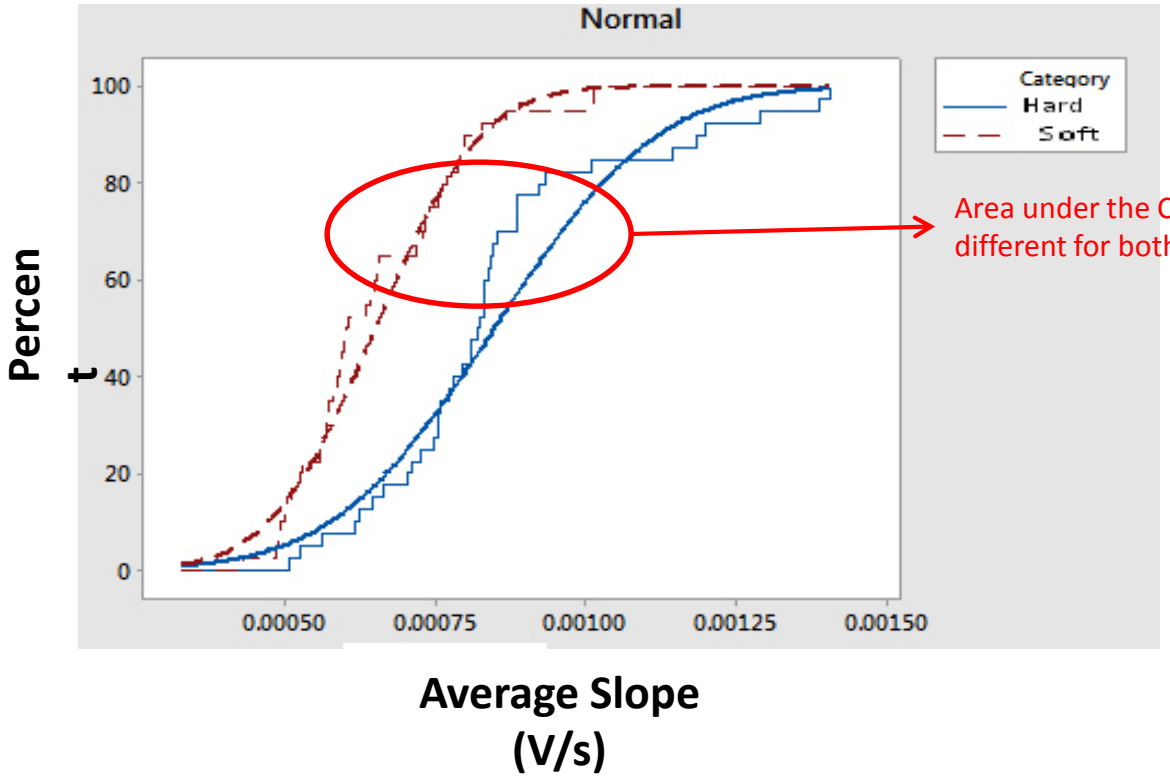




Results Achieved (Contd…)

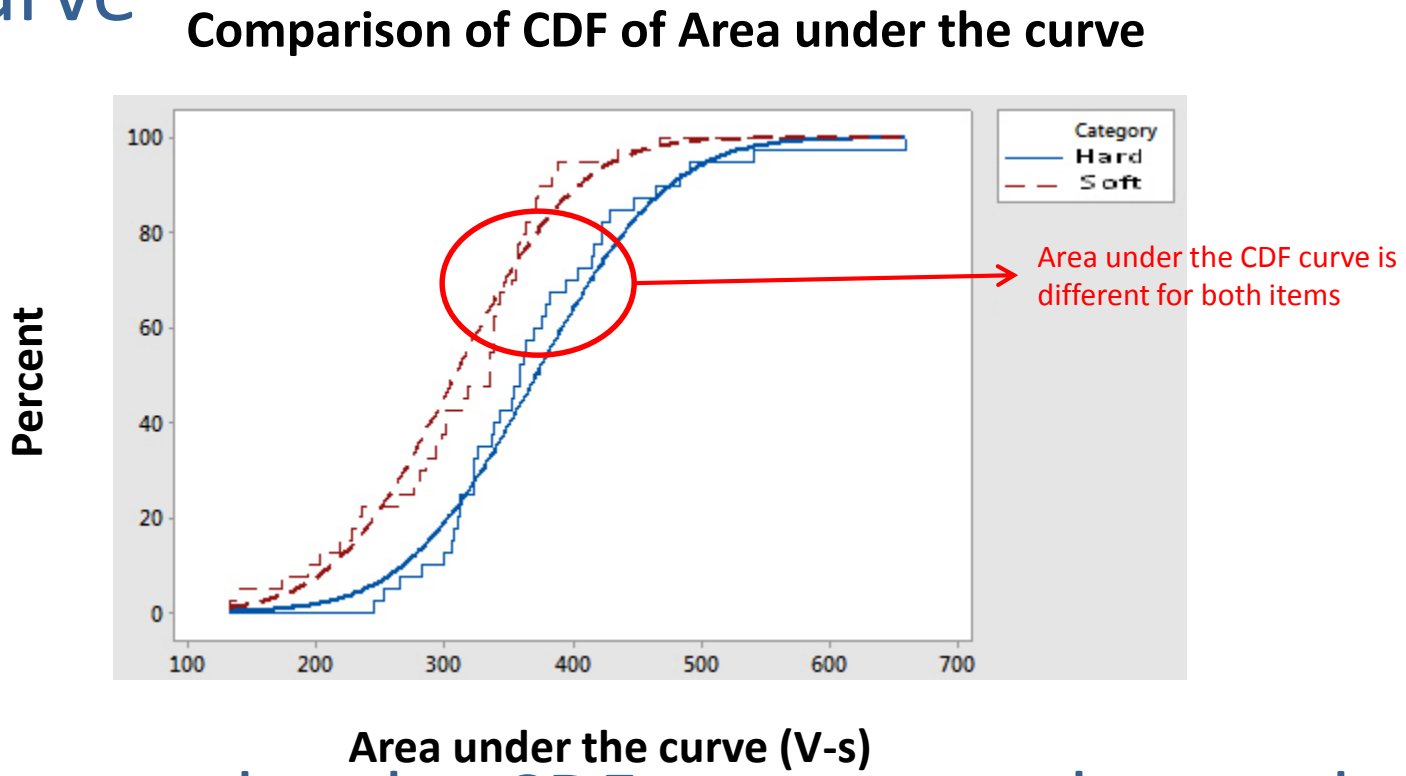
- Statistical Analysis using CDF for Average Slope

Comparison of CDF of Average Slopes



Results Achieved (Contd…)

- Statistical Analysis using CDF for Area under the curve



- The area under the CDF curves can be used to distinguish between hard & soft items

Summary

- SFO successfully demonstrated that a passive sensor can be used to characterize the nature of obstructing material
- Eliminates the need for active sensing methods which are very costly
- The procedure is 100% risk-free and reduce the scope for human error
- Consistent results were obtained even when experiments were non-repeatable

Summary (Contd…)

- MATLAB signal processing was essential for successful extraction of signal parameters
- SG filtering using MATLAB cleans up the signal significantly
- SFO developed a custom autonomous algorithm to extract data from signal using MATLAB
- SFO could extract about 10 different parameters from highly time-varying, non-repeatable signals using MATLAB

Summary (Contd…)

- Statistical analysis of data must be used to differentiate between hard and soft materials
- Statistical parameters provide consistent results even though the experiments are non-repeatable

THANK YOU