Processing data from a visual IoT sensor of Fluid/Structure Interactions with Machine Learning

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Abstract

Water drops impacting cantilevered fibers is a highly complicated system as there are multiple factors that influence the outcome of the interaction. To compensate the complexity of the system, we used machine learning to assist in determining the output of the system. In our project, we specially investigate how much maximum deflection would a fiber string get when impacted by a water drop. To keep the experiment manageable, we have collected in total of 305 data for 3 different fibers with 5 features. Ensemble learning combines ***multiple machine learning algorithms*** to builds a better predictive model. The three algorithms applied are random forest regressor, gradient boosting regressor, and multi-layer perceptrons. Feeding the data into our machine learning algorithm, we were able determine feature's significance and affect to each fiber's maximum deflection.

Methods

- Algorithms are scored using k-folds validation method with 70% data for training and 30% data for testing
- Data set are split into two group: random parameters (279 data) and Design of experiment (DOE) parameters (126 data).
- Scoring metrics were R^2, Relative Error (RE), and Root Mean Square Error (RMSE)
- Used a free video analysis and modeling tool software for results calculation

Experimental Setup

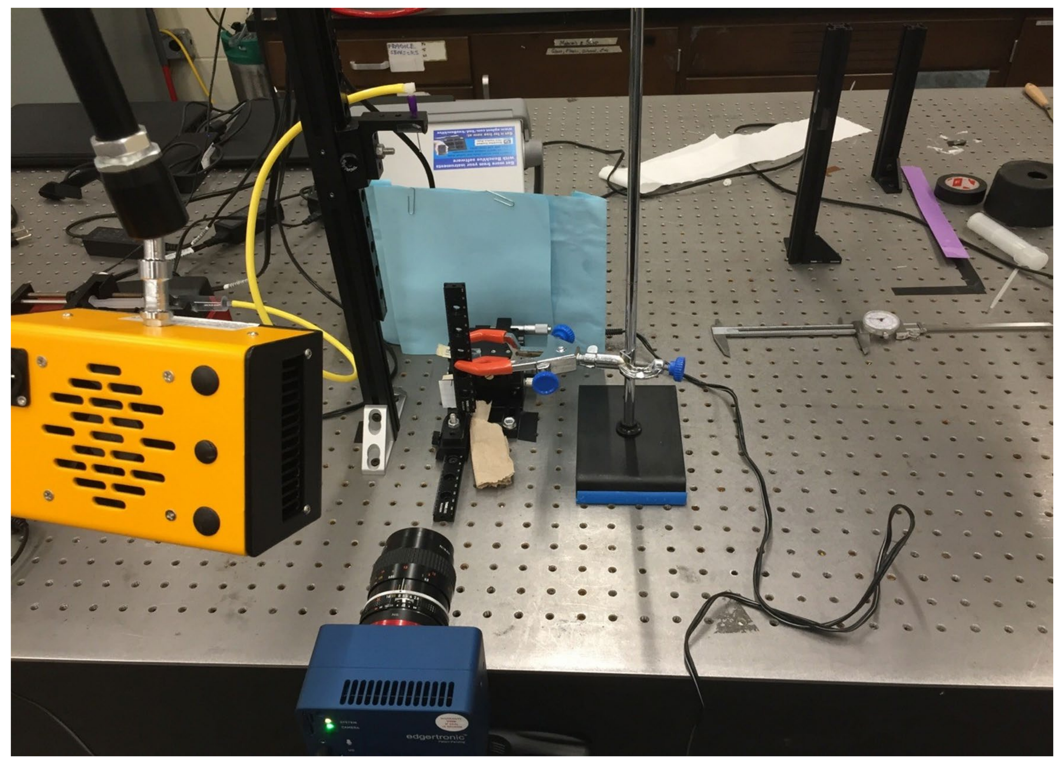

Figure 1: A photo of experimental setup, similar to [2]

- High speed camera (Edgetronic) set directly in front of fiber
- The frame rate of the video 3000 fps
- Light source (GS Vitec LED array) to luminate the experiment setup
- Adjustable platform on table to change effective length
- Adjustable platform on vertical stand to change drop height

Results

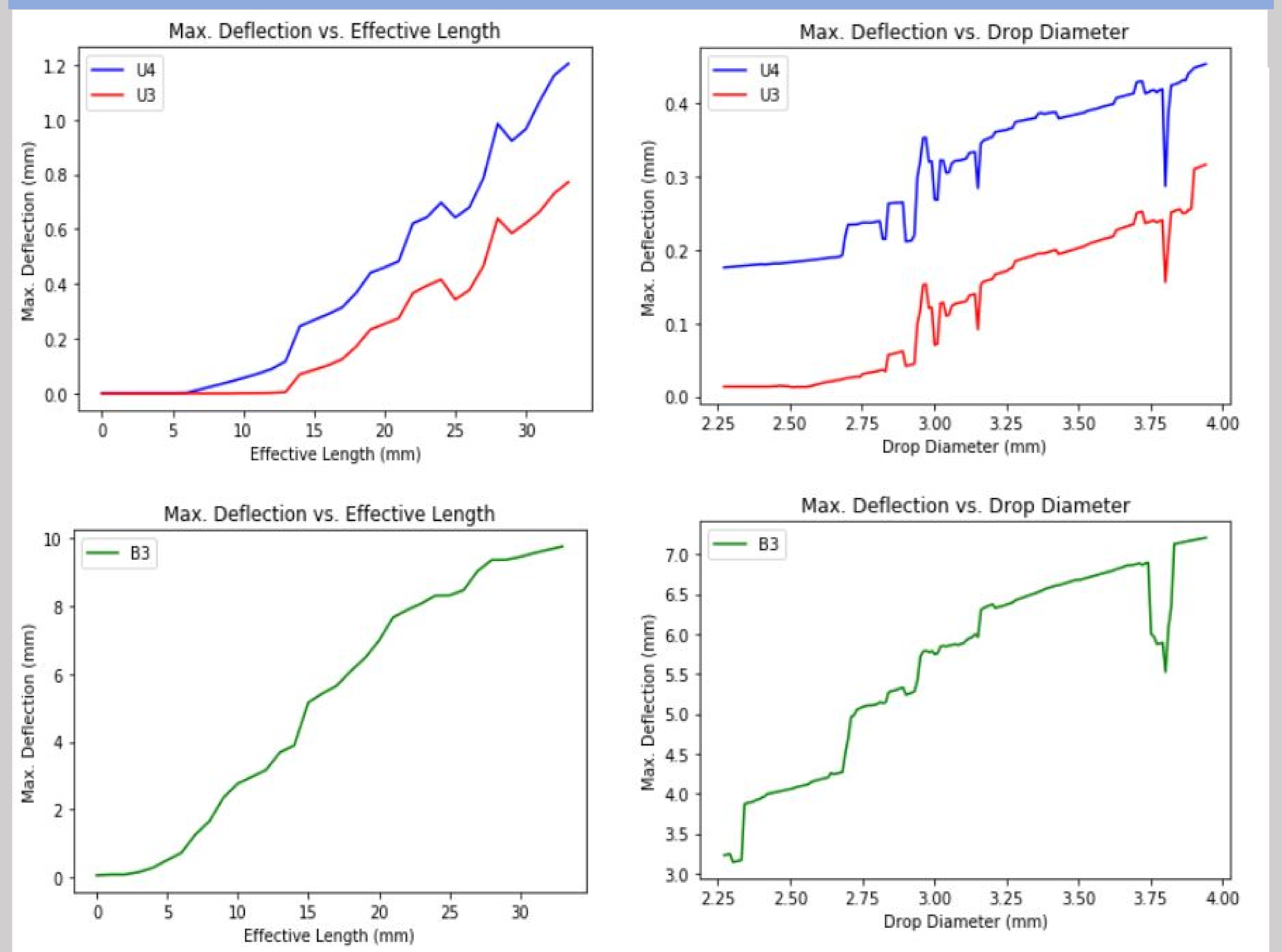

Figure 2: Graphs of the maximum deflection verses length(left) and drop diameter(right)

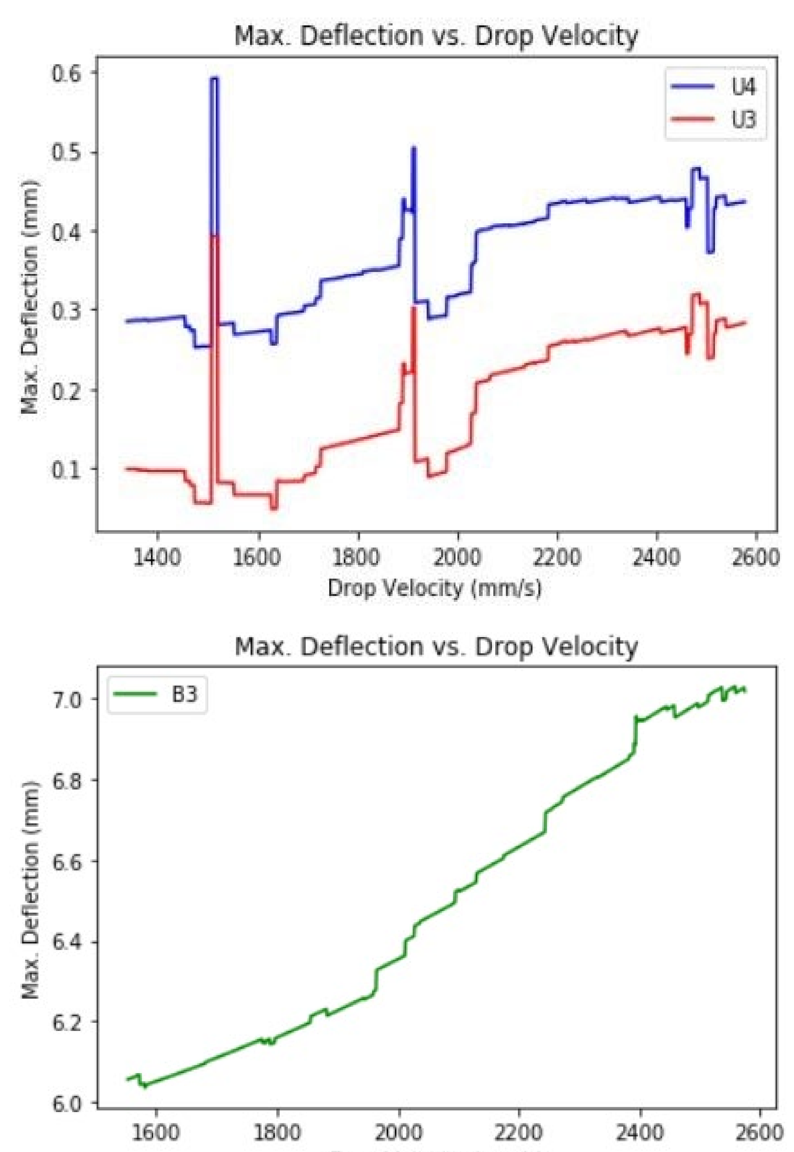

Figure 3: Graph of maximum deflection verses drop velocity(unexpected trend)

Experimented Fibers:

- Rubber string (B3)
- Ukulele 3rd string (U3)
- Ukulele 4th string (U4)

Experimented Features:

- Effective length (L)
- Drop Diameter (D)
- Drop Velocity (V)
- Wettability (W)
- Bending Stiffness (BS)

Ensembled Algorithm score:

- R^2: 0.889
- RE: 123.605
- RMSE: 0.836

Results (Cont.)

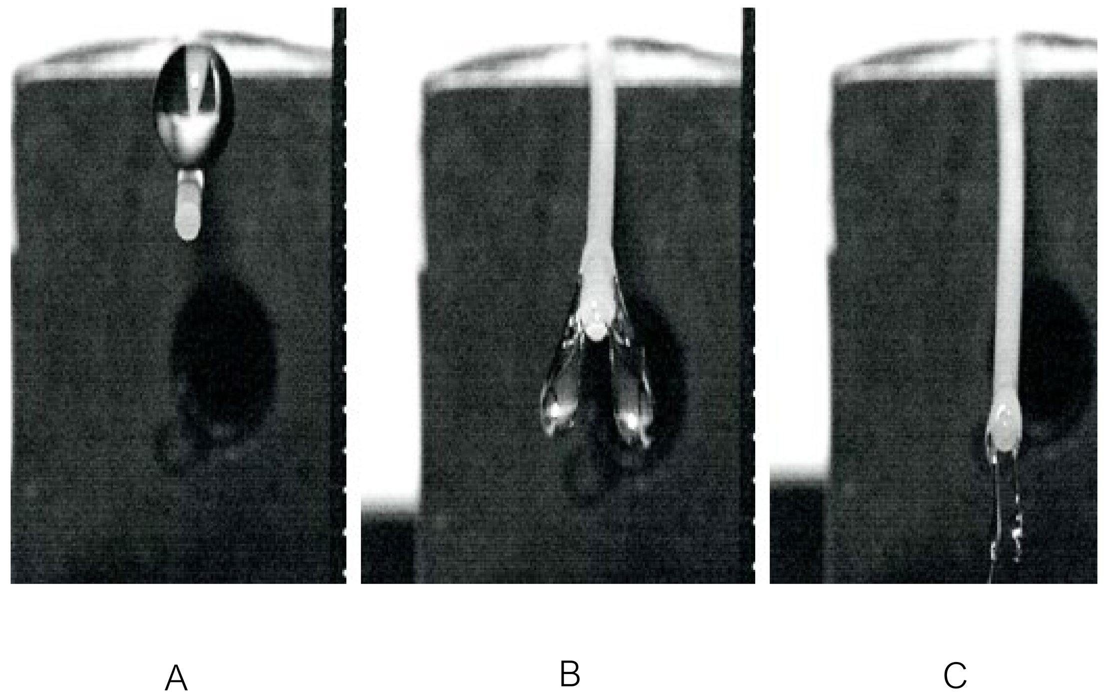

Figure 4: An image of the process of the water drop/fiber interaction. A) Before impact, B) Interaction of water drop/fiber, C) End of interaction [1]

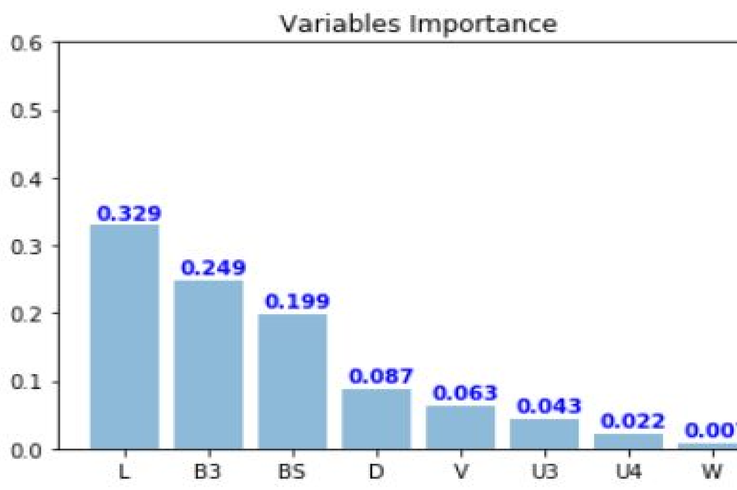

Figure 5: Effectiveness on maximum deflection [3]

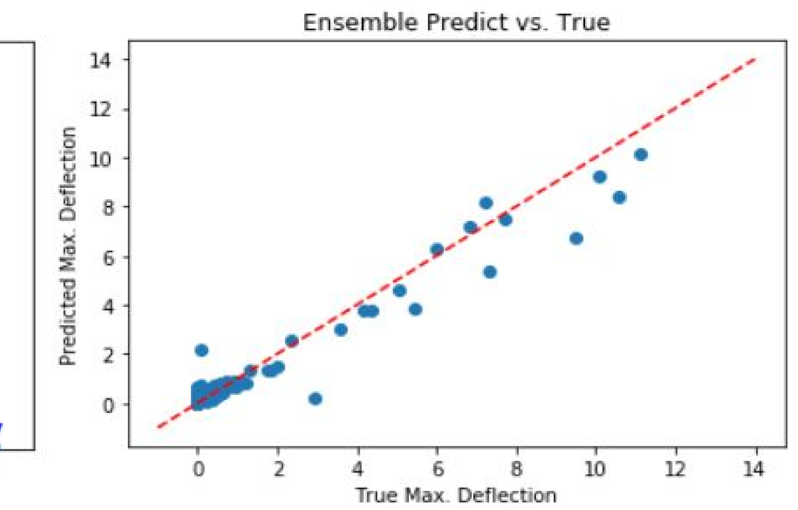

Figure 6: Prediction vs. Observed measurements [3]

Conclusion

- Effective length is the most prominent factor which influence fiber maximum deflection.
- Material with high modulus of elasticity will have over all less maximum deflection.
- Effective length have a positive linear relationship, but starts to exponentially decay when effective length fall before a certain value.
- Drop diameter and Drop velocity have a positive linear relationship with all 3 fiber maximum deflection.

Acknowledgements

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