Non-invasive Soluble Sugar Content Estimation using Millimeter-wave

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Introduction

The development of Internet-of-Things and Artificial Intelligence is promoting a revolution in the way we sense the physical world around us. In the agriculture sector, **estimating the sweetness of food** is a critical concern.

- important in the consumer food market
  - taste
  - healthy diet control
- a good indicator to monitor the sugar intake of animals from fodder [1]. For example, a 5% increase in dietary sugar may reduce milk yield for diary cows [2].

60 GHz mmWave networks have emerged as a potential candidate for designing the next generation of multi-gigabit WLANs [3, 4]. It has its inherent powerful sensing capacity band thanks to the mmWave (30∼300 GHz) [5].

In this poster, we propose:

An initial feasibility study of **non-invasive soluble sugar content estimation** using **60 GHz in-communication-band** millimeter wave signals.

Methods

We investigate the impact of soluble sugar contents of solution on its **reflection properties**, i.e. a reflection loss measurement. Due to the different sugar molecular structure and amount, they will jointly affect the signal reflectivity under the 60 GHz millimeter wave signals. The observation of our measurements coincides with the theoretical models.

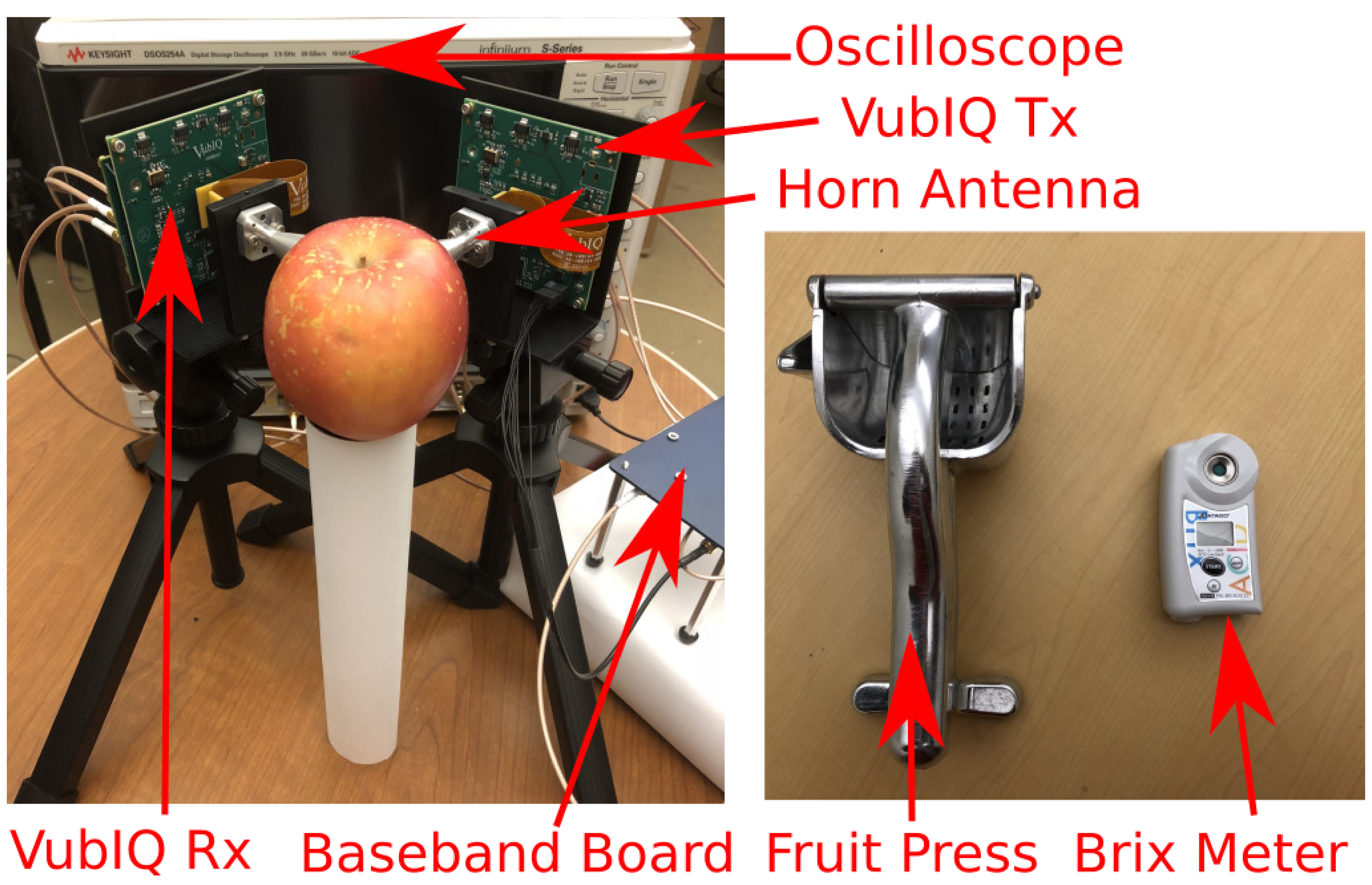
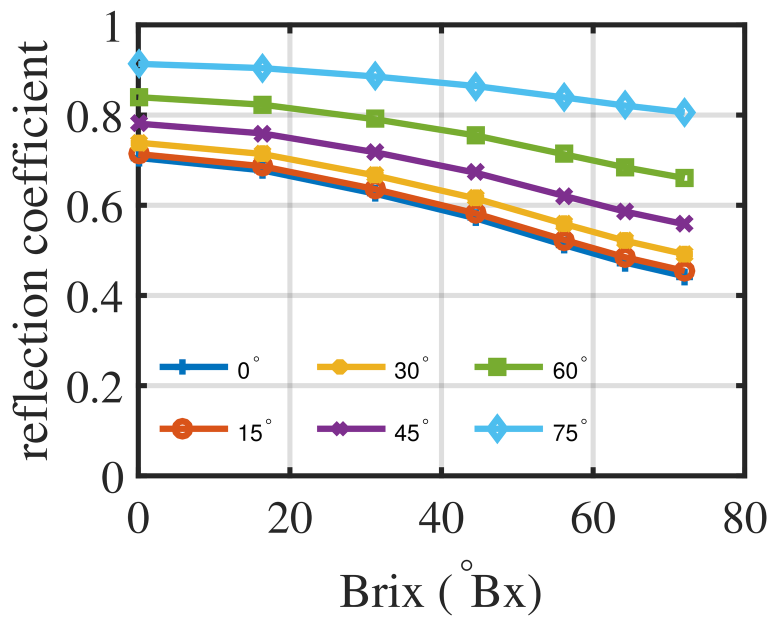


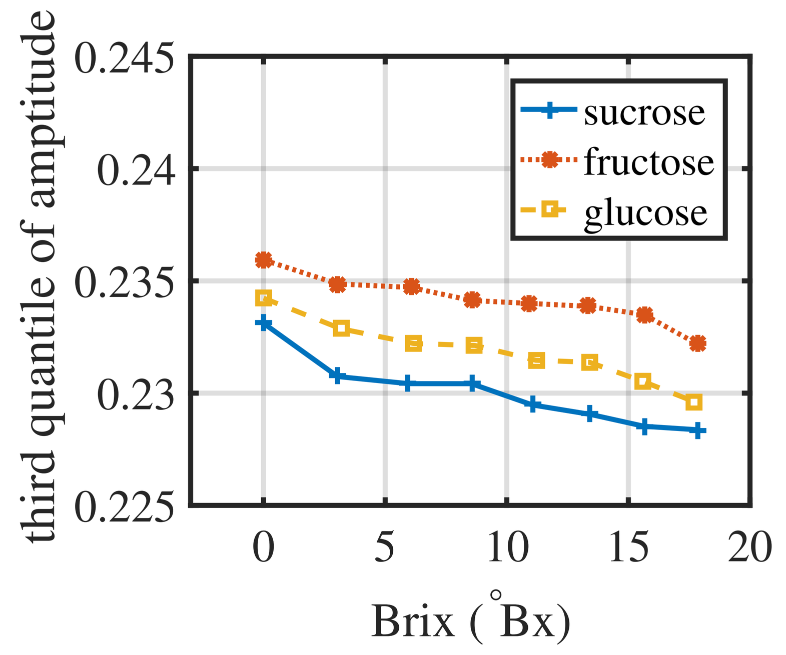
Figure: Experiment set-up

Results

1. Linear correlation coefficients of sugar solution (room temperature at 25°C)



(a) The relationship between Brix of fructose solution and reflection coefficient with different incident angles



(b) Visualization of the relationship between Brix and an example signal measurement feature of three simple sugar solutions

2. Measurement Time and Positions

We select the linear regression model and perform the **5-fold cross validation** on the training set of 80 Fuji samples

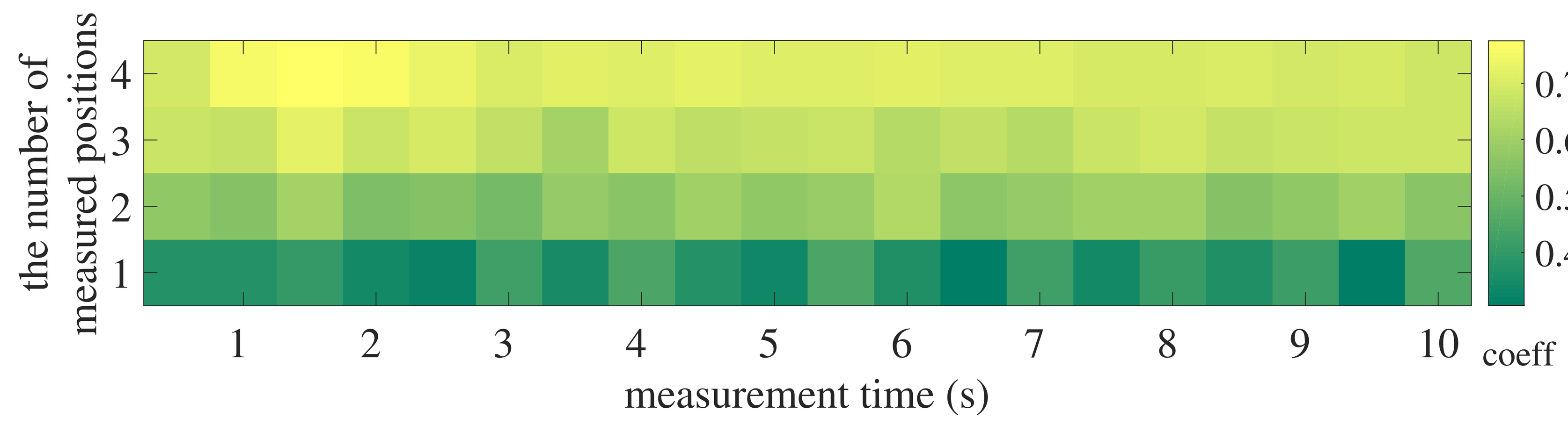
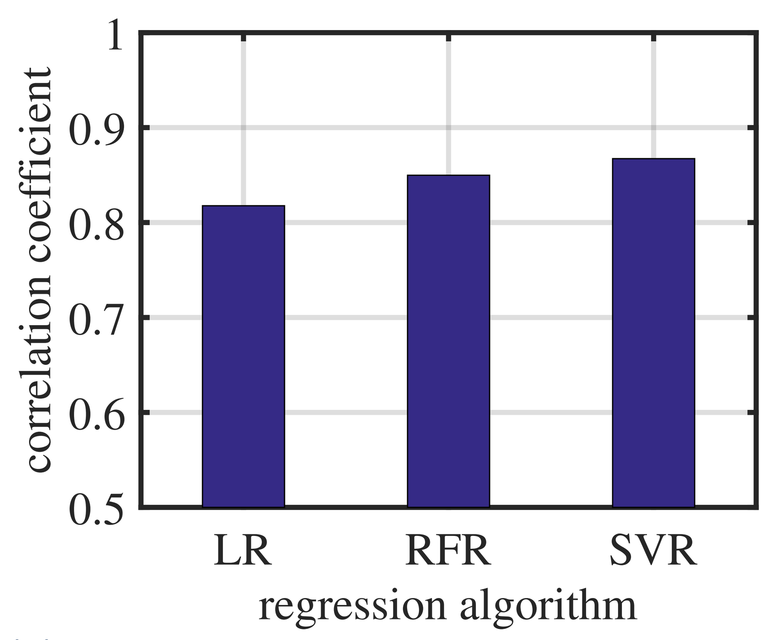


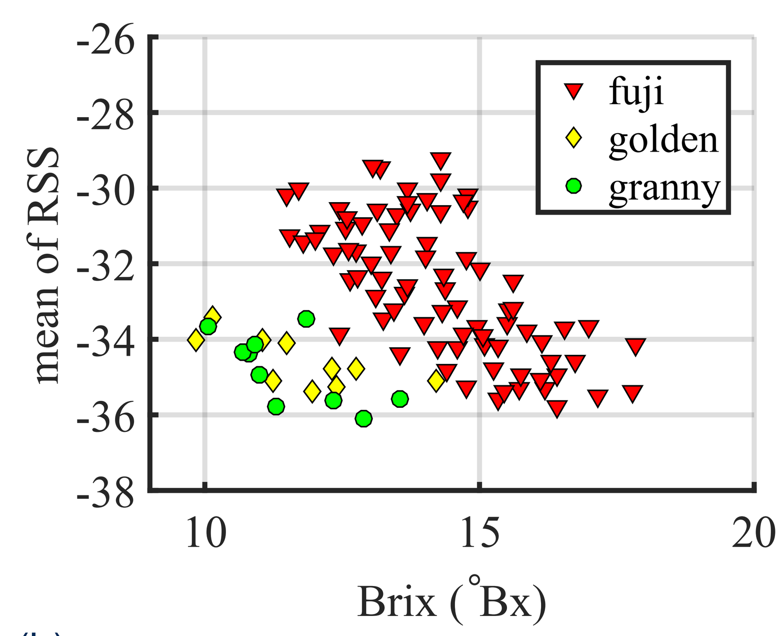
Figure: Heatmap of how long the measurements are taken and how many measured positions needed

3. Linear correlation coefficients of Fuji apples

The sugar content can be accurately measured with a correlation coefficient of **0.8673**, demonstrated by using **100 Fuji apple samples**.



(a) Results of correlation coefficients using different regression algorithms



(b) RSS for Fuji, Golden, and Granny Smith apple samples with different Brix values

References

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[2] Masahito Oba. Effects of feeding sugars on productivity of lactating dairy cows. *Canadian Journal of Animal Science*, 91(1):37–46, 2011.

[3] Zhicheng Yang, Prasant Mohapatra, et al. Sensor-assisted codebook-based beamforming for mobility management in 60 ghz wlans. In *IEEE MASS 2015*, pages 333–341, 2015.

[4] Zhicheng Yang, Prasant Mohapatra, et al. Sense and deploy: Blockage-aware deployment of reliable 60 ghz mmwave wlans. In *IEEE MASS 2018*, pages 397–405, 2018.

[5] Zhicheng Yang, Prasant Mohapatra, et al. Vital sign and sleep monitoring using millimeter wave. *ACM TOSN*, 13(2):14, 2017.