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Estimating the drop width based on side view dynamic measures

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The analysis of sliding drop videos have emerged as a valuable tool for investigating physical phenomena (1-3). Hereby, automatic image processing enables the extraction of various measures from these videos (4, 5). On homogeneous surfaces, hydrodynamic dissipation increases with velocity. Recently, Li et al. studied drops sliding down an inclined surfaces (3) and reported an empirical equation that describes the velocity-dependent friction force:

$F_f = F_0 + \beta w U \eta$ (1)

Where, F_0 is the friction force extrapolated to velocity $U = 0$, β is a dimensionless friction coefficient, w is the width of the droplet while sliding, and η is the viscosity of the liquid. The geometry of drops and their kinetic contact angles sliding down an inclined plane change with velocity. These parameters can be readily measured in side view. However, monitoring drop width in sliding drop experiments typically requires additional equipment such as a camera or mirrors, which limit the effective sliding length in videos from 5 cm to 1.5 cm. Therefore, the slide length can only be investigated partially and sections of the slide length might be missed where defects on the surface are present. A method to estimating the drop width based on side view dynamic measures is required.

We investigated the use of different regression and multiple multivariate sequence analysis (MMSA) models to estimate drop width based solely on side view measures. Our results demonstrated that temporal dependencies play a crucial role in this use case, with the LSTM model outperforming the other models tested. The LSTM model achieved a best result of 67 µm based on root mean square error (RMSE), whereas the regression model achieved a best result of 109 µm. When taking into account the full range of actual drop width values, an RMSE of 67 µm translates to an error rate of roughly 5%. This finding suggests that the LSTM model is a promising approach for accurately estimating drop width in sliding drop videos without requiring additional equipment. In particular, the LSTM model enables accurate estimation of drop width for the entire 5 cm sliding length.

References:

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