Fluorescence spectra of Ukrainian beers: machine learning exploratory study

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Introduction

Beer is one of the most popular beverages in the world. It is produced in both large-scale breweries and small craft breweries. Both types of production, as well as distributors, need cost-effective and consistent ways to control and verify the authenticity of the beverage. Traditional methods for assessing beer properties are often expensive and resource-intensive [1]. Recently, the industry has turned its attention to machine learning-based classification, which has contributed to the development of fast, non-contact and automated approaches for beer quality assessment based on spectral data.[2]

Method and Dataset

The luminescence spectra were taken using a prototype spectral device developed by one of the authors, consisting of a 3D-printed case, a 5 mW 405 nm laser, and a CLMG-7205 spectroscope.
The Origin 2018 software package was used to digitize the obtained luminescence spectra.

The paper explores the potential of a home-made spectral device in combination with machine learning to determine a number of quality properties of beer produced by Ukrainian breweries using luminescence spectra. The spectra of 29 samples of Ukrainian mass and craft beers were taken. For the selected classes, the values of accuracy and sensitivity metrics were determined, and the model's overfitting and ability to detect positive cases were evaluated.

ML classification models (KNN, Decision Tree, Random Forest) were applied to classify the samples according to such properties as the scale of the production (industrial vs. craft), storage condition (can vs. bottle), and fermentation type (top vs. bottom).

Results

- Not all models demonstrate decent accuracy, although the performance of the decision tree algorithm in discrimination between the mass-produced and microbrewery-produced beers is quite high (accuracy 0.777, sensitivity 0.888). Similarly, the algorithm discriminates well between high- and low- type fermentation beers (accuracy 0.766, sensitivity 0.832).
- Based on the ratio of the test and train accuracy metrics the performance of the models is restricted by a small number of samples tested.

Conclusions

- The results of the study indicate that machine learning methods can be useful for classifying fermented beverages according to some of their properties.

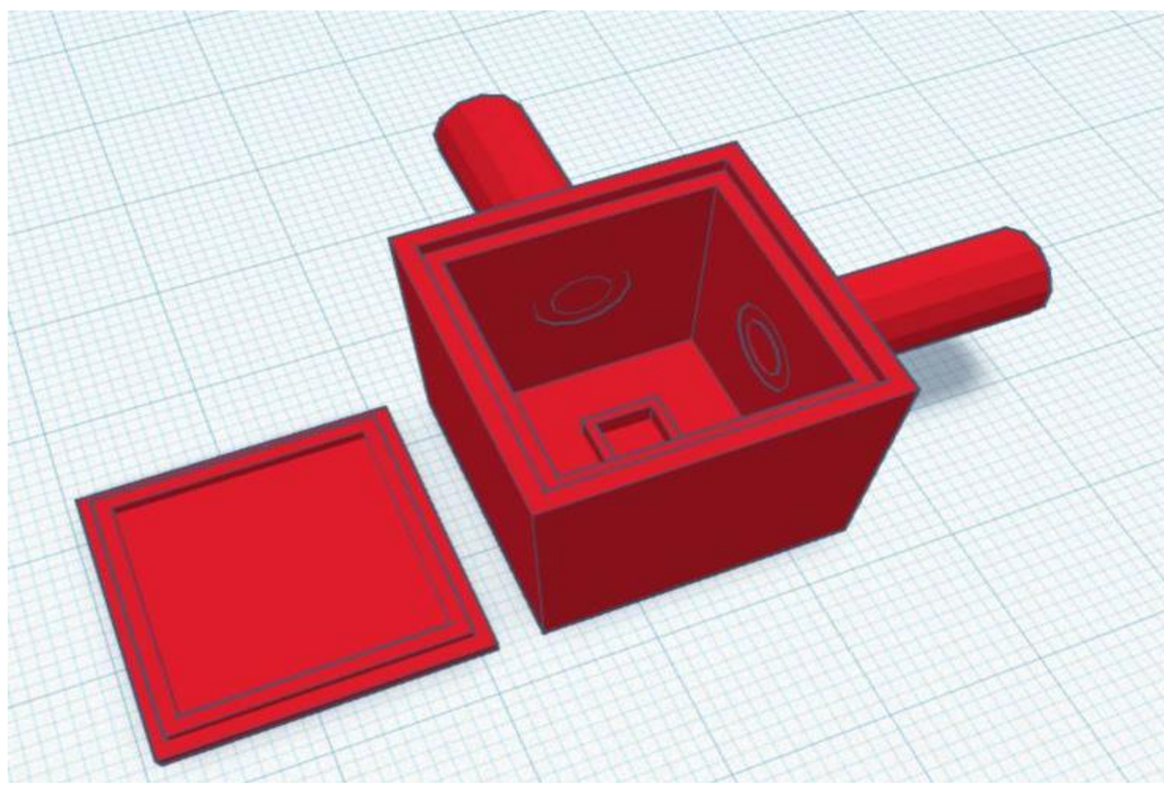

Figure 1 3D model of the optosensor platform housing.

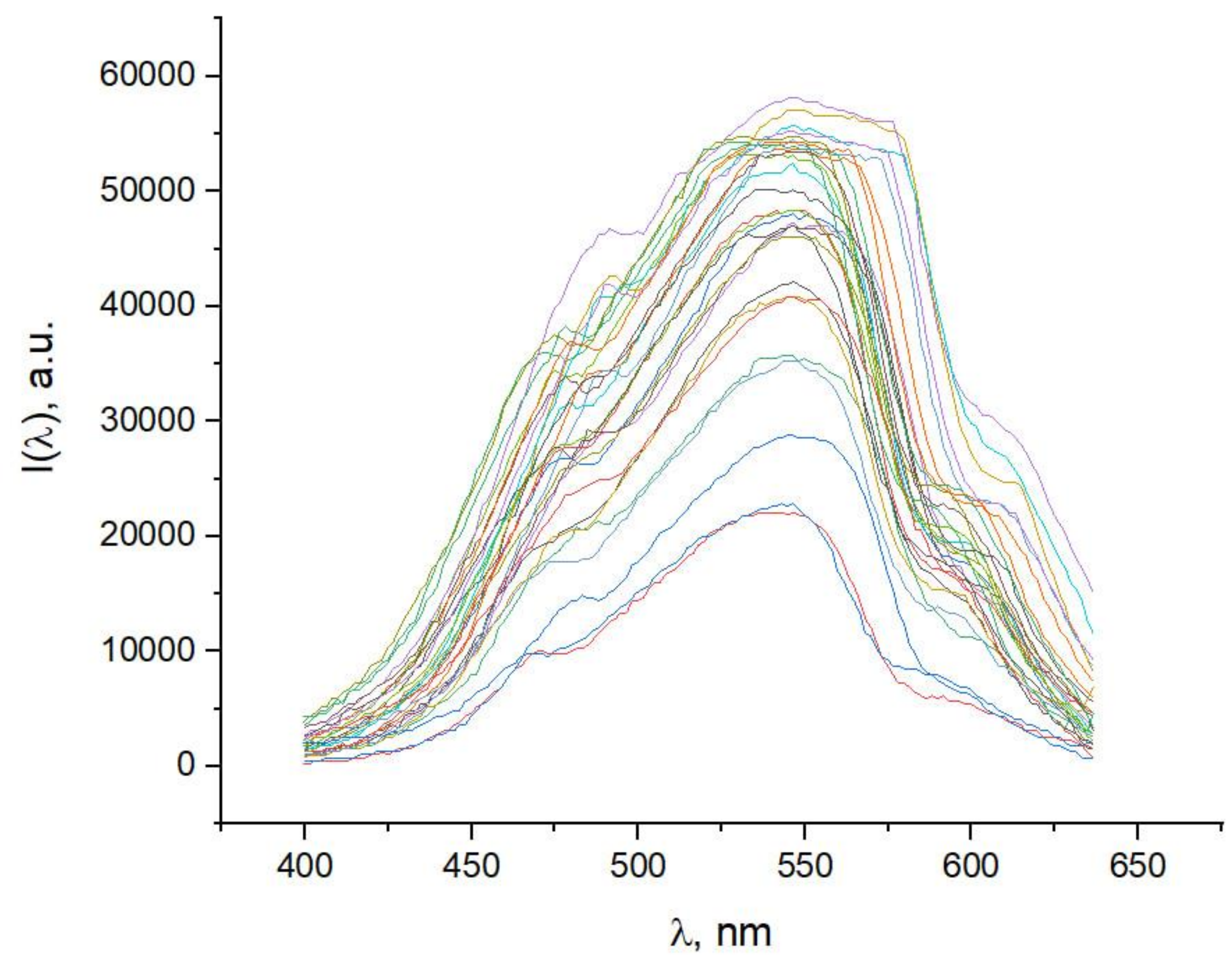

Figure 2 Fluorescence spectra for 29 beer samples.

		Type of beer (High vs. Low fermentation)	Scale of production (Craft vs. Mass Produced)	The packaging (Glass vs. Al can)
KNN	Accuracy (Train)	0.837	0.915	0.896
	Accuracy (Test)	0.622	0.648	0.746
	Sensitivity	0.327	0.629	0.782
Decision Tree	Accuracy (Train)	1.0	1.0	1.0
	Accuracy (Test)	0.766	0.777	0.699
	Sensitivity	0.832	0.888	0.803
Random forest	Accuracy (Train)	1.0	1.0	1.0
	Accuracy (Test)	0.642	0.738	0.762
	Sensitivity	0.416	0.833	0.752

Table 1 Accuracy and sensitivity metrics for the fluorescence spectra based on KNN, Decision Tree, Random Forest models

References:

[1] Gonzaler V.C et al, Journal of the Science of Food and Agriculture , 2018, 98.2, pp. 618-627.
[2] Gao, Yi-Fang, et al. Food Chemistry, 2024, X 22, pp. 101300