Technical Article 2

Predicting the Whiteness Index of Cotton Fabric with a Least Squares Model

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Introduction

This study aims to produce a multi-output least square support vector regression (MLSSVR) model using bleaching process variables and results obtained from two different case studies are used to predict the whiteness index (WI). Figure 1 shows the flowchart explaining the bleaching operation, post-treatment of fabric samples, colour, and bursting strength measurements. In general, the yellowish-brown of cotton is visually associated with soiling or the lack of cleanliness and it is an attribute that must be removed. In order to maintain the whiteness degree of cotton fabric, bleaching is one of the main methods. Hydrogen peroxide (H_2O_2) is one of the commonly used bleaching agents and is highly effective to oxidise the colouring matters. After the bleaching process, the WI that indicates the whiteness degree of the cotton will be measured. The factors that affect the WI of the bleached cotton fabric are time duration, the temperature of the bleaching process, and the concentration of H_2O_2. In the MLSSVR model development, these factors are served as the input variables and the WI is the targeted output variables. Then, the accuracy of LSSVR is evaluated by calculating the coefficient of determination (R^2), root mean square error (RMSE), and absolute mean error (MAE). After that, the obtained results were compared with partial least square regression (PLSR), predictive fuzzy model, locally weighted partial least square regression (LW-PLSR), and locally weighted kernel partial least square regression (LW-KPLSR) models.

Results and discussion

For case study 1, an LSSVR model that is called MLSSVR was developed using several key parameters of the bleaching process, and these parameters including H_2O_2 concentrations, temperature, time duration, and WI of cotton fabric samples are nonlinear. All results from these regression models and the fuzzy method for case study 1 are summarised in Table 1 for comparison purpose and the results for fuzzy method were adopted from [1]. Case study 2 is very similar to case study 1 except one additional parameter which is the bursting strength of cotton fabric samples was included to build MLSSVR model. Meanwhile, all results for the regression models and fuzzy method for case study 2 are tabulated in Table 2. All developed MLSSVR, PLSR, LW-PLSR and LW-KPLSR models are executed using MATLAB while the fuzzy method is utilising a fuzzy logic designer app in MATLAB. The $RMSE_1$, MAE_1 and R^2_1 are the results for the training dataset while the $RMSE_2$, MAE_2 and R^2_2 are for the testing dataset. As shown in Tables 1 and 2, notice that MLSSVR model provided the best results. Besides, for testing data set, the fuzzy method performed better than PLSR, LWPLSR, and LW-KPLSR in case study 1. This result can be seen from the $RMSE_2$ and MAE_2 for the fuzzy method are lower and its R^2_2 values are higher in Table 1. However, in Table 2, the fuzzy method performed poorer than PLSR, LW-PLSR, and LW -KPLSR. These regression models work better than the fuzzy method since the fuzzy logic designer app in MATLAB can only correlate the query that is within the given training data range.

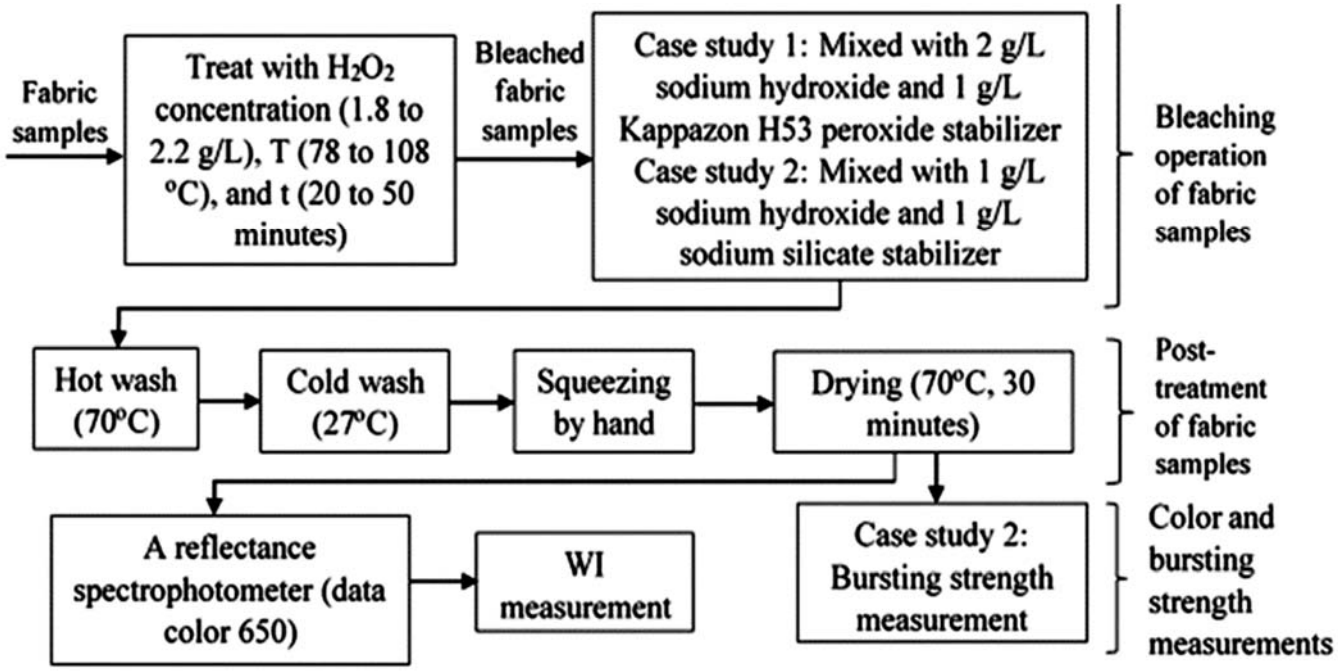

Figure 1: *Flowchart explaining the bleaching operations, post-treatment of fabric samples, color, and bursting strength measurements*

Moreover, LW-PLSR and LW-KPLSR demonstrated better results than the fuzzy method and PLSR. This result may be due to the presence of locally weighted algorithm in both LW-PLSR and LW-KPLSR which improves their predictive performance for the training data. In addition, the overall results show that the fuzzy method worked badly compared to MLSSVR. These results may be due to the helps of the Leave-one-out model in the MLSSVR to determine the optimal tuning parameters and the RBF kernel function that helps to map the original data into a high dimensional space for better prediction of the nonlinear data. Hence, it can conclude that MLSSVR is an effective method to predict the WI using the bleaching process parameters.

Conclusions

Based on these two case studies, the results show that MLSSVR model is a potential predictive model for the bleaching process in the textile domain. The detailed study can be found in Yeo and Lau [2]. For future study, an integration of a locally weighted algorithm in the MLSSVR model could be expected to enhance its predictive outcomes.

References

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***Table 1**: Comparison of the results obtained from different models for case study*

Results	MLSSVR	Fuzzy method	PE (%)	PLSR	PE (%)	LW-PLSR	PE (%)	LW-KPLSR	PE (%)
Kernel function	RBF	–	–	–	–	–	–	Log kernel	–
$RMSE_1$	**0.1606**	0.7373	359	2.1014	1209	0.3335	108	0.4755	196
MAE_1	**0.1126**	0.6133	445	1.5981	1320	0.2560	127	0.4088	263
R^2_1	**0.9985**	0.9673	3	0.6469	35	0.9934	1	0.9863	1
$RMSE_2$	**0.3339**	0.5358	60	1.2194	265	0.8122	143	0.6714	101
MAE_2	**0.2388**	0.4781	234	1.0427	337	0.7101	197	0.5861	145
R^2_2	**0.9829**	0.9549	3	0.8357	15	0.9103	7	0.9334	5

***Table 2**: Comparison of the results obtained from different models for case study*

Results	MLSSVR	Fuzzy method	PE (%)	PLSR	PE (%)	LW-PLSR	PE (%)	LW-KPLSR	PE (%)
Kernel function	RBF	–	–	–	–	–	–	Log kernel	–
$RMSE_1$	**0.0408**	3.3523	8107	2.1117	5070	0.2304	464	0.4025	885
MAE_1	**0.0274**	1.5914	5706	1.5815	5670	0.2024	638	0.3311	1108
R^2_1	**0.9999**	0.4206	58	0.6589	34	0.9970	0.30	0.9906	0.93
$RMSE_2$	**0.2972**	6.4790	2080	1.8877	535	0.8185	175	0.9051	205
MAE_2	**0.2302**	6.1358	2566	1.6081	599	0.7822	240	0.8721	279
R^2_2	**0.9810**	– 0.1150	112	0.6828	30	0.8825	10	0.8337	15

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