Food model exploration through evolutionary optimization coupled with visualization: application to the prediction of a milk gel structure

Lutton, E., Tonda, A., Gaucel, S., Foucquier, F., Riaublanc, A. , Perrot, N.

Introduction and objectives

Replicating "in silico" the structuring dynamics of gel formation stabilized by proteins is a relevant challenge for a better understanding of those complex systems.

Nevertheless, in order to exploit the potentiality of the models, effective means to visualize the space of possible solutions must be used. As models of food processes become more and more complex, it also becomes harder for the experts to thoroughly explore their behavior and find meaningful correlations between parameters. If sensibility analysis approaches are powerful tools to answer to a part of this problem, they do not allow the global visualization of the nature of the link taking place between variables. This information may nevertheless be relevant for a better understanding of the law involved in the mechanisms under study.

Methodology Example

While an analytical study is often impractical, graphical visualization tools can help the user to better understand the behavior of the model, as well as the possible improvements to be performed. Nevertheless, an effective way to explore the model behavior must be employed. In this paper, we propose an approach to model exploration that couples visualization with evolutionary computation. The case study is a model devised to predict milk gel structures, based on a system of differential equations with a total of 5 parameters to be set by the expert. Sensitivity analysis on the model has been already presented in previous works.

Results and discussion

During the experiment, several meta-data are extracted and made available to the expert: the space distribution of all candidate solutions proposed by the evolutionary algorithm; the space distribution of all optimal candidate solutions; and global data on the space distribution of the points, for each parameter of the model. We show that, using the proposed approach, experts are able to reduce the dimension of the model, eventually finding a correlation between two of the variables. Reverse-engineering the final outcome of the experiment, the emergence of such a pattern is explained by physical laws underlying the oil-in-water interface colonization. Thus, the proposed approach shows an improvement over the results of the sole sensitivity analysis.

Conclusions

While the present work is focused on milk gel modeling, the described methodology can be generalized to any kind of phenomenon, and can greatly assist the experts in better assessing the behavior of their models.

References

- Dickinson, E. Emulsion gels: The structuring of soft solids with protein-stabilized oil droplets, Food Hydrocolloids 28 (2012) 224-241.
- Foucquier, J., Chantoiseau, E., Le Feunteun, S. Flick, D., Gaucel, S., Perrot, N. Food Hydrocolloid 27 (1) (2012) 1-13.
- Lutton, E, Foucquier, J, Perrot, N, Louchet, J and Fekete, JD. 2011. Visual analysis of population scatterplots. In 10th Biannual International Conference on Artificial Evolution (EA-2011), Angers, France.
- Perrot, N., Trelea, I.C., Baudrit, C., Trystram, G., Bourgine, P. Trends Food Sci Tech 22 (6) (2011)304-314.
- Surel, C., Foucquier, J., Perrot, N., Mackie, A., Garnier, C., Riaublanc, A., Anton, M. To appear. Composition and structure of interface impacts texture of o/w emulsions, Food Hydrocolloids