An inverse problem in the demulsification of oil-water mixtures

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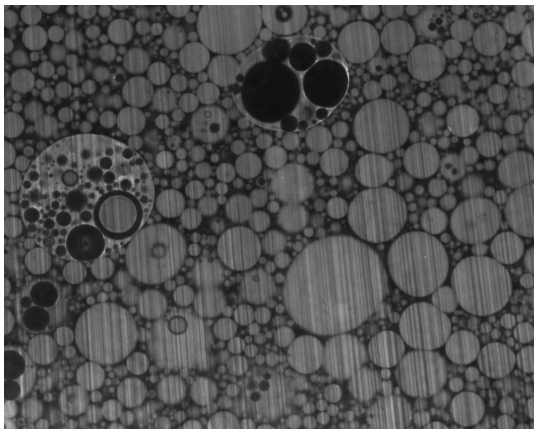

Figure 1: Sample data from Petr's lab

Project Outline and Objectives

When oil and water are mixed together by turbulence they form a complex multiphase fluid with bubbles of one medium embedded inside bubbles of the other, often in a recursive fashion. The process whereby the two de-mix by a process of successive coagulations of like-type bubbles is called demulsification. If you can work out how to make it happen faster then oil companies like BP will pay you a lot of money.

Petr Denissenko has some really neat movies of the demulsification process obtained by shining a laser sheet through a mixture of oil and water which has been mixed. A typical frame is shown above. The objective of this project is to extract the evolution of the droplet size distributio as a function of time using these frames. This will involve two steps. First some edge-detection techniques will have to be adapted to extract the radii of the circles from images like the above. Then a probabilistic inference will have to be done of the most likely radii of the bubbles assuming that the bubbles are sliced uniformly by the laser sheet.

If this all goes well, the second objective of the project is to use this data to learn the shape of the droplet coagulation kernel by assuming that the coagulation can be described by a mean-field Smoluchowski equation using methods recentlyt developed by myself and Robin [1]. This is almost certainly wrong due to the spatial structure of the emulsion but will provide a good starting point for further modeling.

Required Background and Methodology

This project requires some knowledge of computer data analysis and a willingness to learnig something about image processing, filtering and edge detection. Some interest in machine learning and inverse problems would be a plus.

Research Outcomes

If we can make this work, then Petr has got some further funding lined up from BP to do more careful experiments.

PhD prospects

Possibility to continue with Petr in engineering subject to finding another co-supervisor since I will be away next year.

References

[1] Peter P. Jones, Robin C. Ball, and Colm Connaughton. A nonlinear least squares method for the inverse droplet coagulation problem. *arXiv:1301.4863*, January 2013.