MUCCA – Multi-disciplinary Use Cases for Convergent new Approaches to AI explainability

Report I – TEAM MANAGEMENT

27 November – 18 December, 2020

Partner 5 – University Politehnica of Bucharest, RO
REOROM Laboratory; PI – Prof. Corneliu Balan

I.1 General presentation

MUCCA – Multi-disciplinary Use Cases for Convergent new Approaches to AI explainability is a project included in the CHIST-ERA III programme[1], section: *Explainable Machine Learning-based Artificial Intelligence (XAI).* Duration of the project is 36 months, starting with the end of 2020 or beginning 2021, depending of each partner.

CHIST-ERA is a coordination and co-operation activity of national and regional research funding organizations mainly in Europe and is supported by the Horizon 2020 Future and Emerging Technologies (FET) programme of the European Union through the ERA-NET Cofund funding scheme.

Principal objective of the MUCCA project is to develop and test methodologies that allow to interpret the predictions of the AI algorithms in terms of transparency, interpretability, and explainability. An interesting set of multidisciplinary use-cases in which explainable AI (xAI) can play a crucial role and that will be used to quantify strengths and highlight, and possible solve, weaknesses of the available explainable AI methods in different applicative contexts. The proposed use-cases range from High Energy Physics AI applications, to applied AI in medical imaging, to AI applied for the diagnosis of pulmonary, tracheal and nasal airways diseases, to machine-learning techniques of explainability used to improve analysis and modelling in neuroscience. End-to-end pipelines, one or more for each use case, implementing the full analyses/application chain will be designed and implemented. In each pipeline state of the art available xAI methods together novel xAI algorithms will be included and performances evaluated. The ultimate goal would be to be able to bring together different techniques and methods from algorithmic xAI, physics, and simulation, to provide the best tools and to synthesize a unique and transferable knowledge base on the use of xAI methods providing engineering xAI pipelines for general use. The pipelines will be provided as a visual analytics framework for explainable AI. The framework will enable users to understand deep learning models and to diagnose model limitations using different explainable AI methods, as well as to refine and optimize the models. In the pipelines several monitoring tools will be integrated, to control quality, model comparison, and trust building.

The MUCCA consortium is formed by 6 partners:

1. **University Sapienza of Rome** (coordinator)
2. **Istituto Nazionale Fisica Nucleare, Rome, Italy**
3. **Medlea S.r.l.s., Rome, Italy**
4. **University of Sofia "St. Kl. Ohridski", Bulgaria**
5. **University Politehnica of Bucharest, Romania**
6. **University of Liverpool, U.K.**

Partner 5 is represented by the **REOROM – Complex Fluids and Microfluidics Laboratory**, a research unit founded and directed since 2000 by Professor Corneliu Balan.

The expected results of the MUCCA project are: (i) to bring together different techniques and methods from algorithmic xAI, (ii) to provide a work package (xAI-TOOLS) and technical support, (iii) to synthesize a unique and transferable knowledge base on the use of xAI methods needed for all the use-cases under investigations.

[1] https://www.chistera.eu/projects-call-2019

The contributions of the REOROM group are the following:

1. Characterization of the mucus/saliva rheology in confined domains;
2. Reconstructions of the analyzed respiratory airways – flow visualization and velocity measurements;
3. Comparison between experiments and simulations performed by Medlea software products DigiScan (Partner 3) to optimize the model both at analytical level and by proper numerical treatment;
4. xAI algorithm to predict the global airflow resistances in respiratory conduits.

I.2 Team presentation

The team's members, their role and responsibilities in the project are presented in Table 1.1

NAME	POSITION	PERIOD	Role	Responsibilities
Corneliu Balan	Professor	2020-2023	Principal Investigator	Coordinator
Diana Broboana	Professor	2020-2023	Co-investigator	Numerical simulations, administration
Nicoleta Tanase	Asoc. Prof.	2020-2023	Co-investigator	Numerical simulations, modeling, website responsible
Claudiu Patrascu	Ph.D student	2020-2023	researcher	Experiments (responsible), modeling
Eugen Chiriac	Ph.D student	2021-2023	researcher	Numerical simulations contact P2, Experiments
István Magos	Ph.D student	2020-2023	researcher	Experiments (flow visualizations), numerical code
Titus Sava	Master student	2021-2023	researcher	Experiments (design setup), modeling
Ana-Maria Bratu	Master student	2021-2023	researcher	Experiments (flow visualizations), contact partners
Sanda Maiduc (Osiceanu)	Dr. ing.	2020-2023	technician	Administrative

Tabel 1.1 Team members of the Romanian partner in MUCCA project.

I.3 Qualitative tests of liquid samples

Visualizations of the fluids/soft solids samples in contact with the air flow will be a major task for the REOROM group, directly related with the objectives of our investigations. For that reason, in the first stage of the project (reduced to 3 weeks) have been only tested the experimental setups from the qualitative point of view.

The main setup used to determine the flow field in the vicinity of the surfaces is the stereo-PIV systems (normal and micro), equipped with fast digital cameras for direct visualizations and velocity field measurements. The experimental setup, represented schematically in Figure 1.1, is composed of a glass tank filled with a fluid (air or liquid), a nozzle (with an inner calibrated diameter), a mechanical mechanism which accurately fixes the position of the nozzle and a Harvard PHD Ultra syringe pump. The fluid sample was injected at a constant flow rate which ensured the development of a dripping mode (droplet formation) of the tested fluid that emerges from the nozzle, Figure 1.2. The experimental setup for such measurements requires two cameras and a laser as an illumination source (see Figure 1.1.a). The PIV system is manufactured by Dantec and includes two SpeedSense VEO 340 cameras of 2560 x 1600 pixels resolution. For each experiment, a number of 1500 couples of images of the flow were taken. The laser is an LPY-PIV series having two pulsed and Q-switched Nd: YAG laser resonators. The laser produces a sheet of light of 532 nm and 1 mm in thickness. The fluid is seeded with micro-glass hollow spheres; it is assumed that the motion of these particles follows the flow dynamics. The velocity field is calculated using an adaptive PIV method, which optimizes iteratively the size and shape of each interrogation window to local flow gradients and seeding concentration.

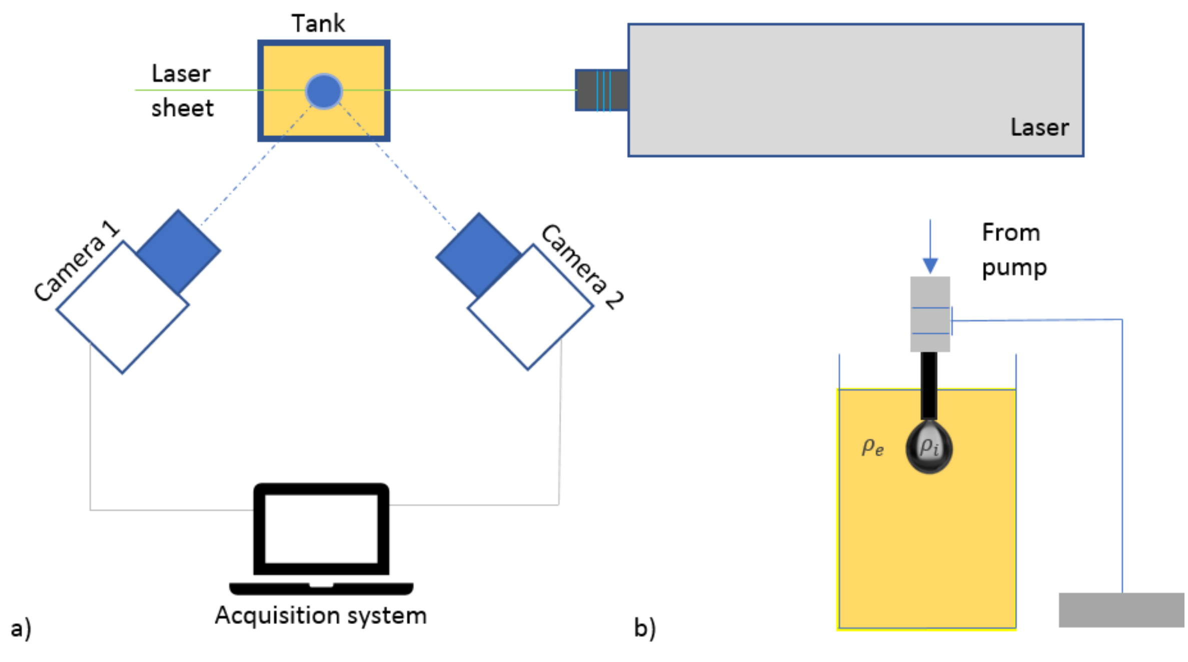

Figure 1.1 a) Top view of the experimental setup for Stereo PIV measurements which includes an LPY-PIV series laser, a tank with oil and seeding particles and two cameras; b) Schematic representation of the tank, nozzle and mechanical mechanism used to create droplets in a viscous outer medium (not to scale). The fluid is injected by a syringe pump at a constant flow rate.

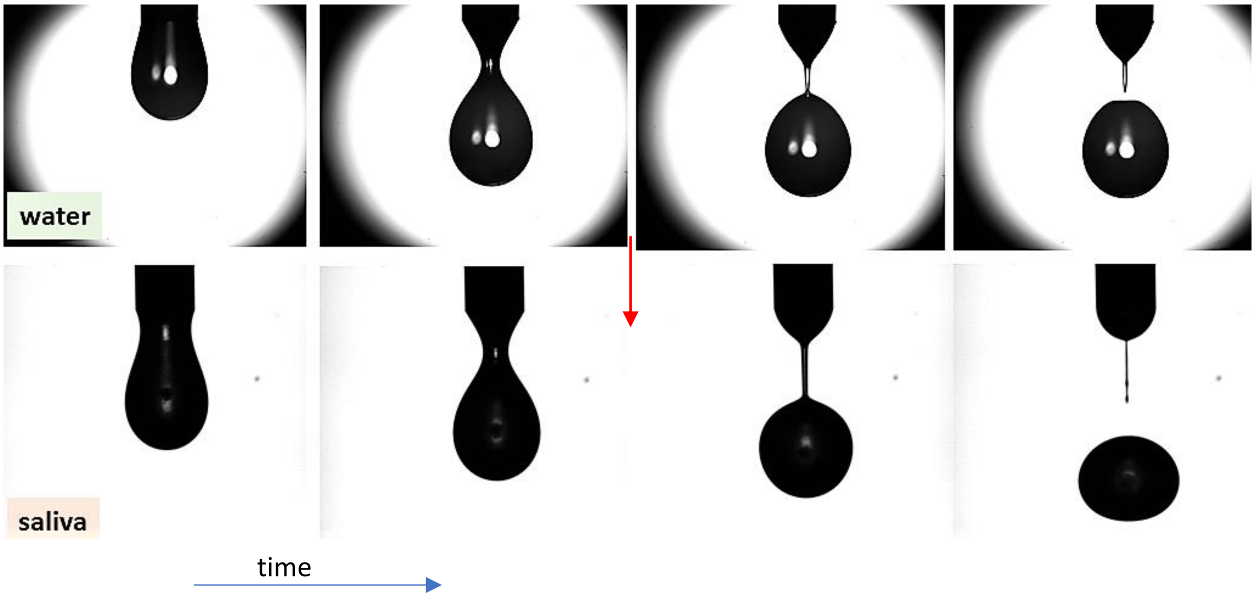

Figure 1.2 Detachment of liquid droplets in air for water (reference sample) and human saliva. The images analyzes of the droplet shapes during the dynamical process is correlated to the rheological properties of the samples (visualizations performed at 4000 fps).

In Figure 1.3 and Figure 1.4 are shown the time evolutions of a soft-solid sample (similar to the human mucus), in contact with a solid wall, under the action of the air current.

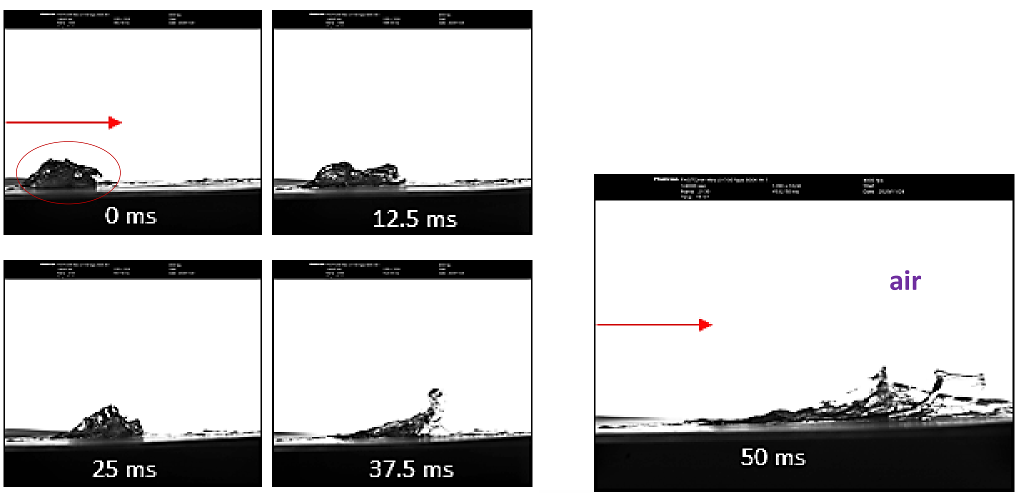

Figure 1.3 Dynamics of Xantan Gum 0.5% sample on a flat surface (initial configuration 1). The speed of the incoming air stream is approximately 3 m/s.

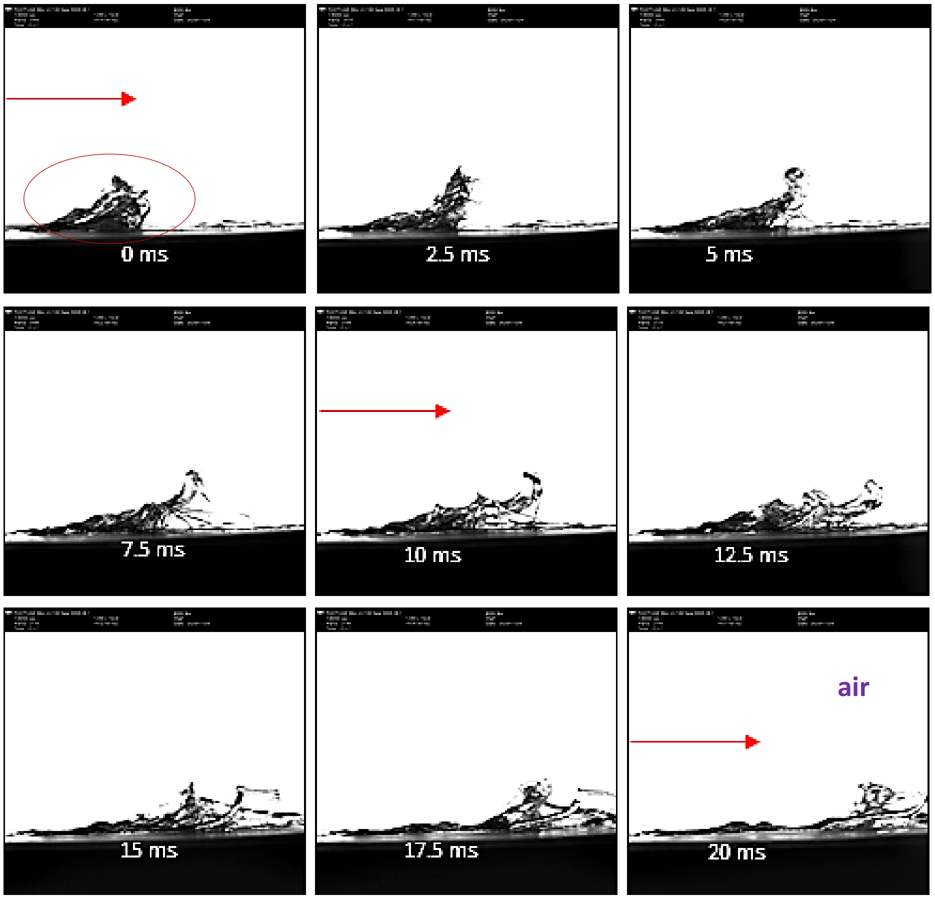

Figure 1.4 Dynamics of Xantan Gum 0.5% sample on a flat surface (initial configuration 2). The speed of the incoming air stream is approximately 3 m/s.

The pictures showed in the previous Figures prove, even if they are only qualitative, the capabilities of the REOROM Laboratory to deliver to our colleagues from MUCCA project value experimental information, which will be used to generate data for the xAI applications.

I.4 Final remarks

The project MUCCA started for the REOROM team in December 2020, the time dedicated to the first stage being reduced to only 3 weeks. The period was mainly used to run properly the administrative work, to share to the team members the duties, to finish the necessary documentation for our university and UEFISCDI (the Romanian agency) and the consortium agreement.

But at the time, we feel to be important to produce some experimental results. Of course, there are only simple qualitative tests, but promising ones. They are a good preamble for the next year work, which is for us the most demanding stage of the project.