Universidade Federal de Minas Gerais
Escola de Engenharia
Curso de Graduação em Engenharia de Controle e Automação

EHDA closed loop control system based on real time non-visual spray mode classification

Relatório de Atividades 3
Projeto Final de Curso

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1 Summary

Electrohydrodynamic Atomization (EHDA), also known as Electrospray (ES), is a way to disintegrate a liquid into droplets by exposing it to a strong electric field. EHDA surveys have contributed as an important tool for the development of water technology (thermal desalination and metal recovery), material sciences (nanofibers and nano spheres fabrication, metal recovery, selective membranes, and batteries), and biomedical application (droplet encapsulation). Besides that, the project is merged with the Energy Transition strategy and Innovation Agenda Agriculture, Water, and Food, Key Enabling Technologies (KETs). Although, there are EHDA applications in industry, stabilizing the cone-jet spray mode is done empirically and based on mean current measurements.

The electric current flowing transported by the spray reveals characteristic shapes for different spray modes. Those shapes cannot simply be summarized by its mean value. In figure one we can see an example of cone-jet mode electrospray.

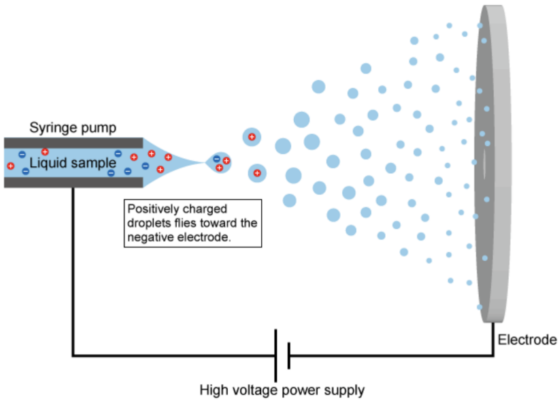

Figure 1: EHDA

Signal processing techniques can allow a non-visual classification of the spray mode based on the electric current shape. The spray process imposes noise and random sequences on the measured signal making its classification not a trivial task.

Industrial applications demand automated stabilization of a spray mode. This can be achieved by a closed-loop control system. Automated classification of the spray mode is a crucial part of a control system same as the development of an appropriate control algorithm. Signal processing implementations of previous projects of the NHL Stenden Water Technology group are showing good classification results. Further research is necessary to improve the classification accuracy and research and implementation of a suitable classification algorithm. Because of that, the work will be done by the Water Technology Group at NHL Stenden University of Applied Sciences and in combination with Dutch companies to match analysis possibilities with knowledge and infrastructure availability.

The setup used for this project can be seen in the Figure 2. To run the experiment automatically it is used a computational processing machine to integrate the peripherals and run their routines, system sensors such as the oscilloscope and the high speed camera and also the system actuators which is represented by the high voltage power supply and the syringe pump.

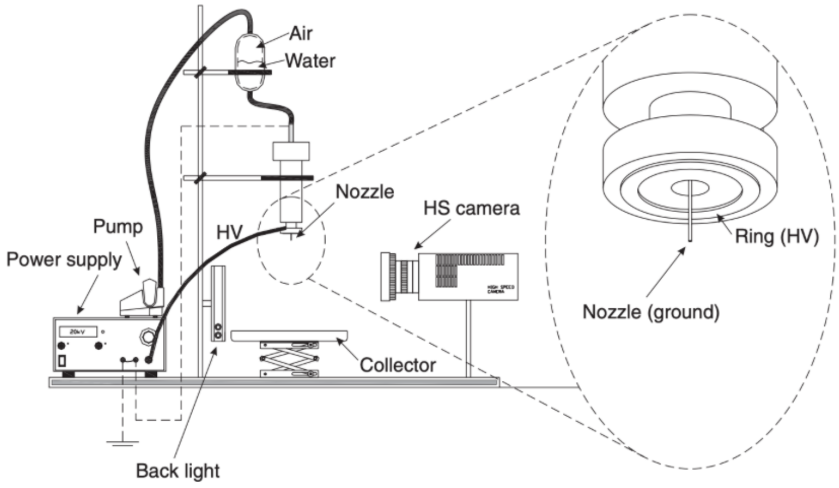

Figure 2: System Architecture

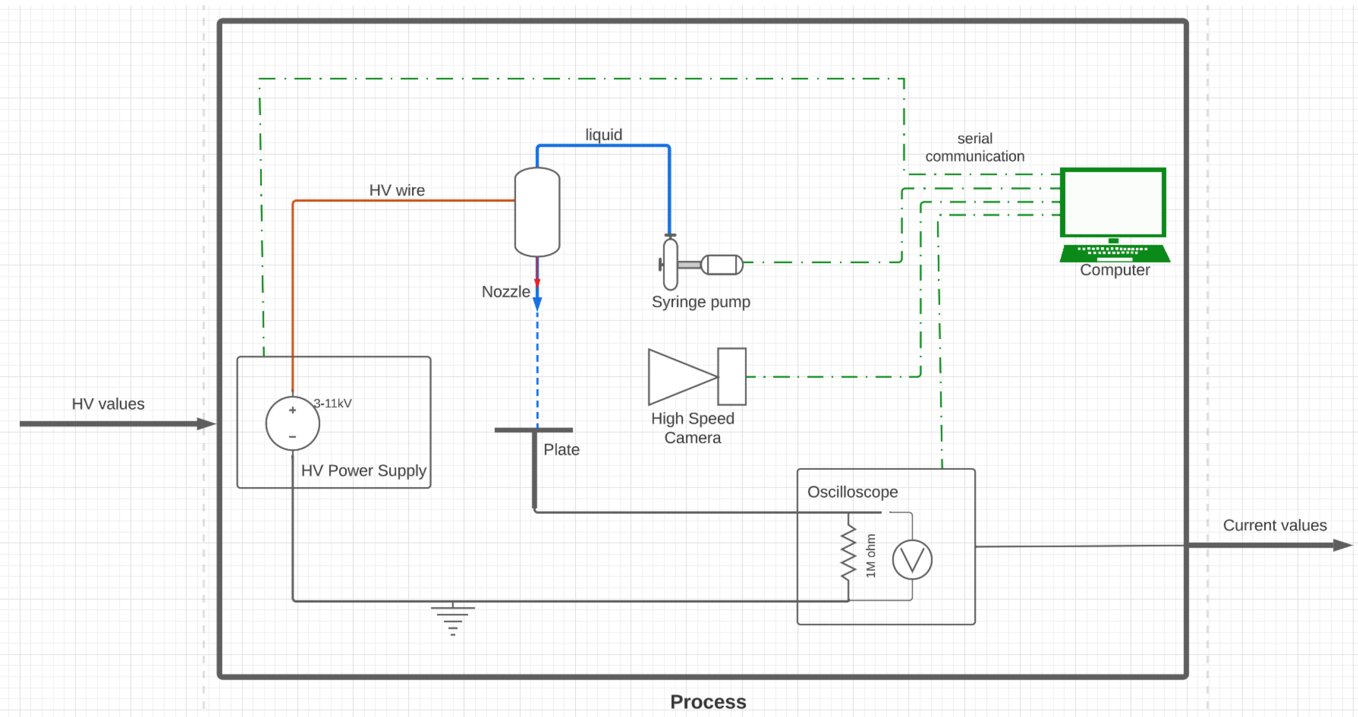

Figure 3: System Design

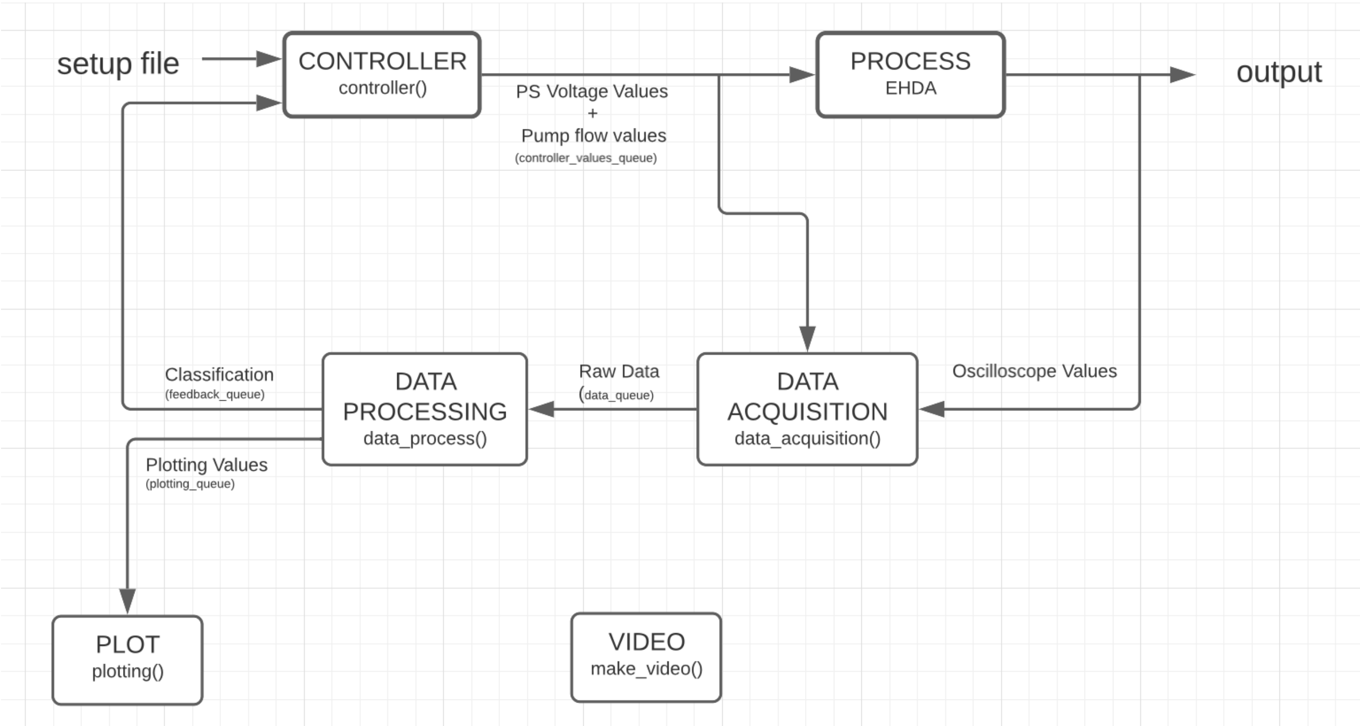

Figure 4: Software Design

2 Metodology and Results

3.1 Pump Integration

The pump integration in the automation algorithm bring us a new controllable variable, the Flowrate. Now we can control the spraying mode with the two main variables that afect the system. It will bring more complexity for the system since now we are dealing with multivariable control. Fortunatelly those two variables are uncuppled (* be certain of that first *) which means that actuating in one of them will not interfere in the other one. Controlling also the flowrate gives to this project a new dimension in the system giving us freedom to explore the flowrate properties.

The pump integration was developed using also python language. As I could not find a good library for this pump I developed an quick and easy interface for sending the pump commands to be integrated with the main automation routine. The communication with the pump was made using the serial interface and the commands list were found in the pump user manual.

3.2 First mapping Experiments

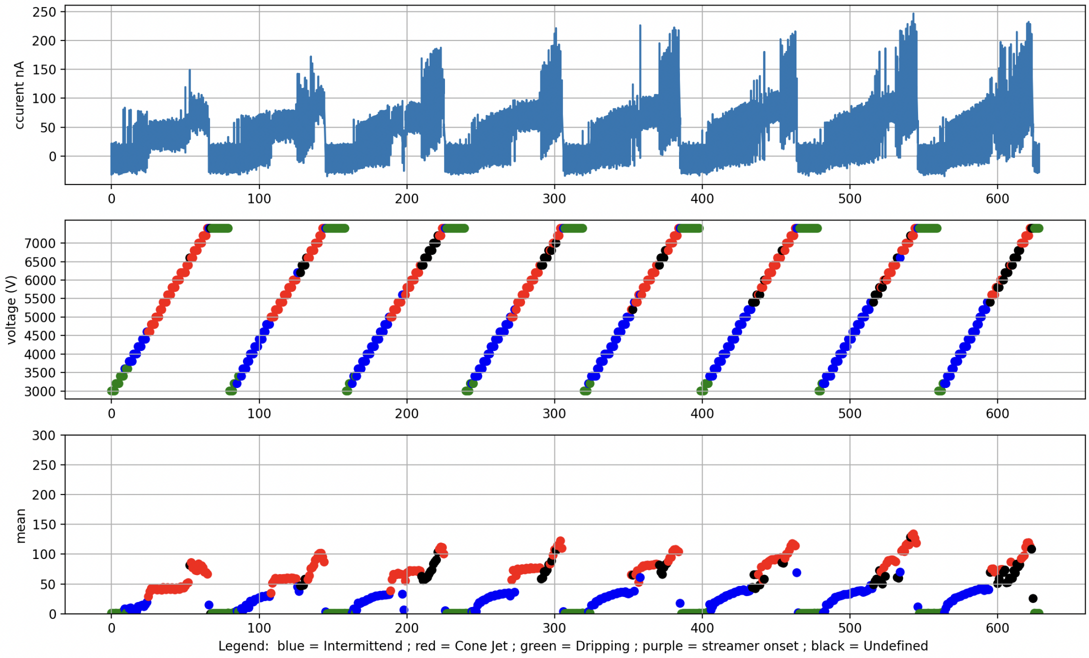

Figure 5: Mapping Experiment data

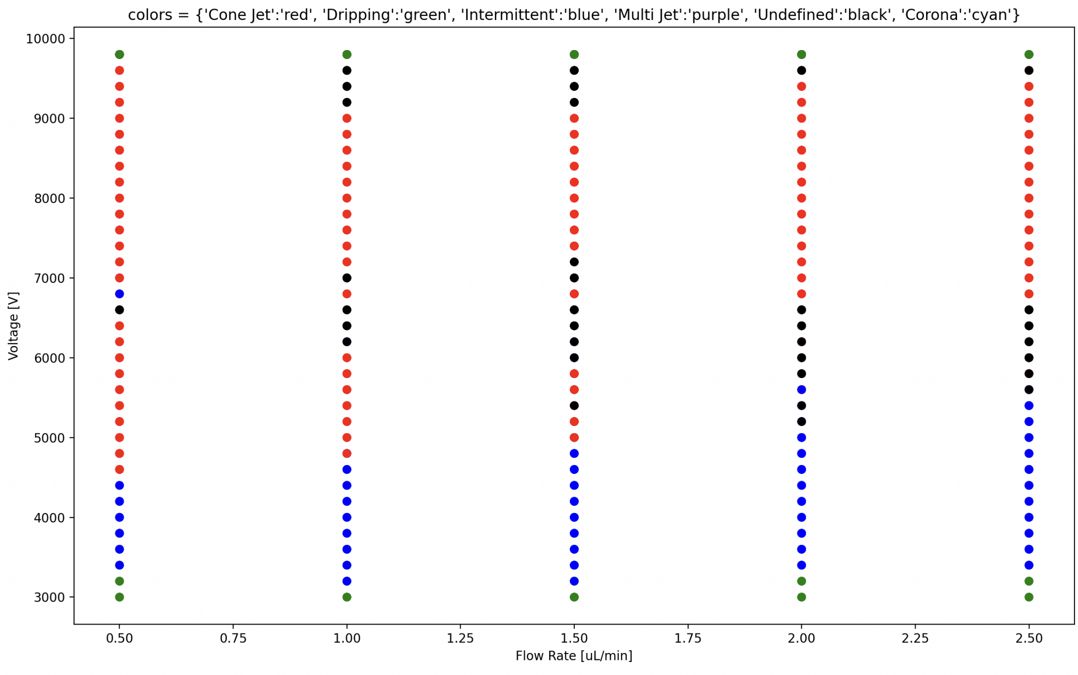

Figure 6: First mapping trial

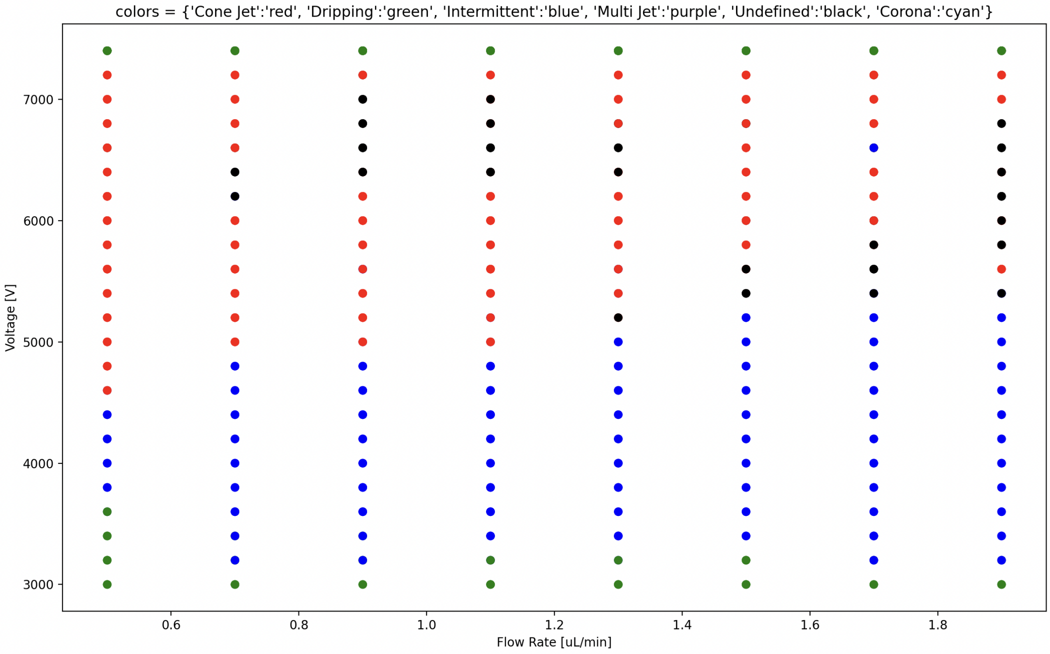

Figure 7: Second mapping trial

It was noticed that the motor of the pump in certains speed generate a noise caused by the stepping from the stepper motor. This noise from the motor was being acquired by the current data and was interfering in the classification method. Because of that the firsts results of the map have a lot of undefined or incorrect classifications. This can be reduced inserting a bubble in the syringe to atenuate mechanical noises.

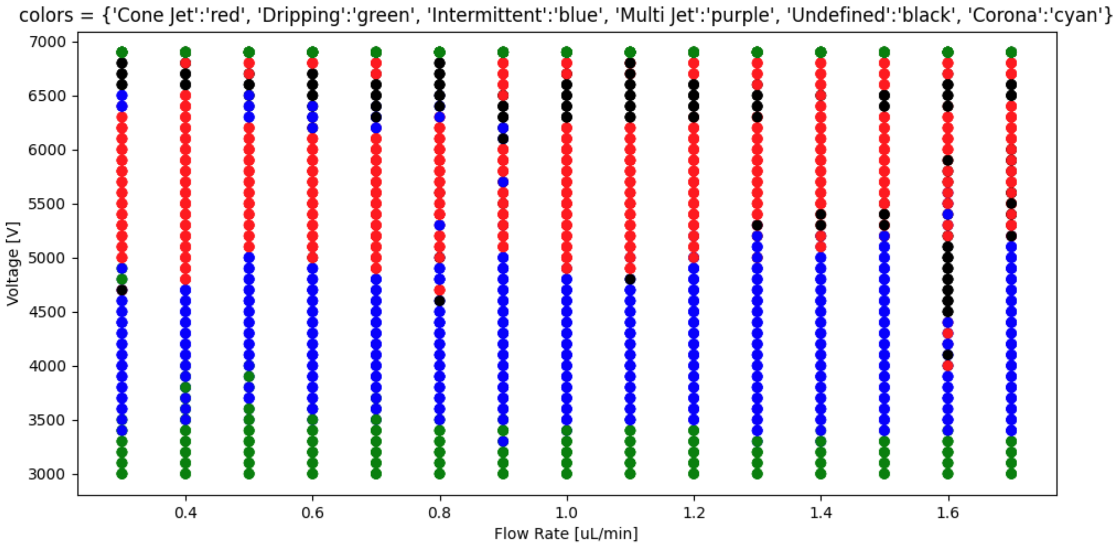

Figure 8: map3

3.3 Step Interference in each sample

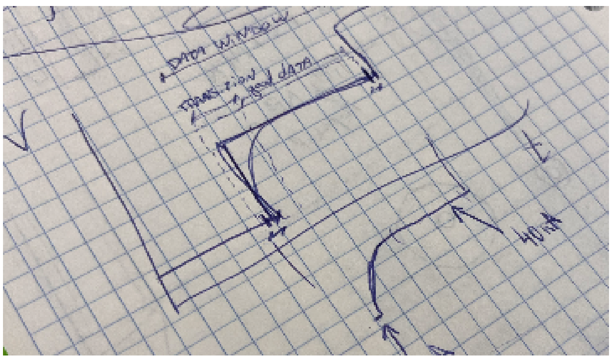

Figure 9: map3 reproccessed data head

we were evaluating the interference of each step in the....

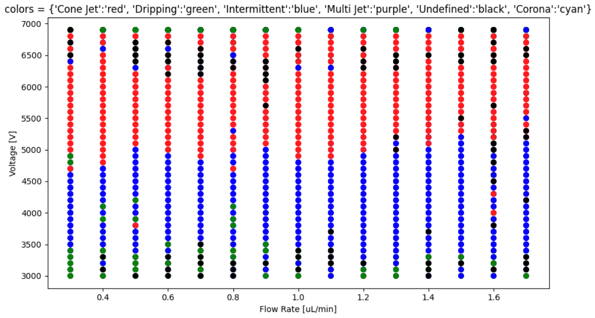

Figure 10: map3 reproccessed data head

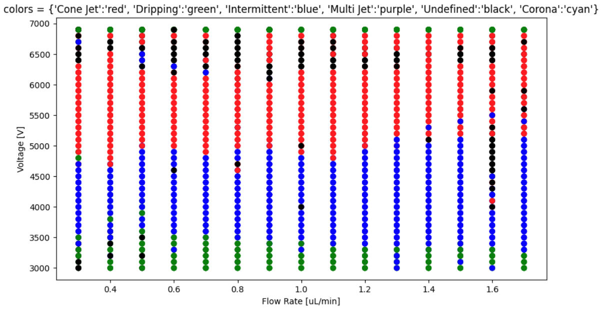

Figure 11: map reproccessed data tail

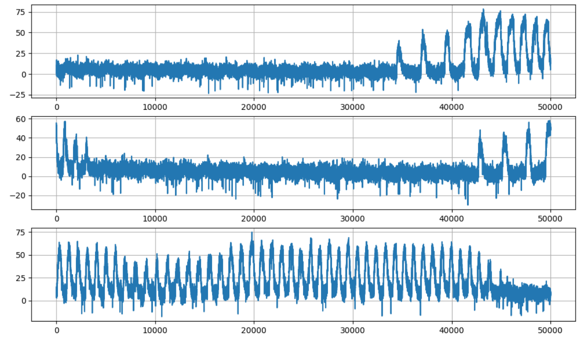

Figure 12: map reproccessed data tail

3 Conclusion

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References

[1] S. Verdoold et al. "A generic electrospray classification". In: *Journal of Aerosol Science* 67 (2014), pp. 87–103. ISSN: 18791964. DOI: 10.1016/j.jaerosci.2013.09.008. URL: http://dx.doi.org/10.1016/j.jaerosci.2013.09.008.