TOWARDS A PROTOTYPE FOR SMART IRRIGATION USING OPTIMAL CONTROL

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1. Introduction – In this work we describe an ongoing project aiming to develop an irrigation management system using optimal control as a main tool. One of its main objectives is to create a prototype of a smart irrigation system to be applied in an agricultural field where many crops are cultivated. The main challenge in the project To CHAIR - POCI-01-0145-FEDER-028247 (see site https://sofialope6.wixsite.com/to-chair), is the study of water management problem as an optimal control problem using and/or developing mathematical tools within the following subjects: statistics, mathematical modelling, numerical optimization and optimal control. Applying a diverse set of tools of these different areas of mathematics to an agronomics problem, is, in itself, an innovative challenge.

2. Results and Discussion - The heart of automatic irrigation system is its control unit and the water dynamics is adequately described by a set of differential equations. The very first attempt to tackle this problem, can be read in Lopes et al. [2011]. In this paper, an Optimization Control Model (OCM) was developed to obtain an irrigation plan for a field of potatoes located in the Lisbon area, consisting in optimizing the irrigation water by means of optimal control with inequality constraints, so that the water amount in the soil (trajectory) fulfils the water requirements of crop of potatoes cultivation. Afterwards, the OCM suffered several modifications considering for example the recalculation of a new dynamic based on the addition of real data for rainfall after determining the optimal solution. In Lopes et al. [2018], the authors address the daily irrigation problem for minimizing water consumption. This problem has the particularity that dynamics is described via field capacity modes which can model the different dynamics of a soil, saturated or not. It was carried out an analysis to ensure that the normal Maximum Principle for non - smooth problems can be applied to this problem and it was observed that the numerical solution fulfils the necessary conditions of optimality. Recently, in Lopes et al. [2019], it was developed a daily irrigation plan model for a crop field using optimal control. This daily plan model had in consideration: weather data (temperatures, rainfall, wind and speed), the type of crop, the location, soil humidity at the initial time, the type of soil and the irrigation type. Here, we also intended to minimize the water from irrigation systems ensuring that the field crop is kept in a good preservation condition. The mathematical model was implemented in MatLab/Octave. Results for moisture of the soil and the necessary irrigation were compared with experimental ones obtained from a real grass field in Portugal. This comparison allowed us to validate our model:

- the real moisture of the soil have a similar behaviour to the estimated solution using real data for irrigation;
- the water used in irrigation obtained from our model, allows to save water resources, keeping the crop safe.

3. - **Conclusions –** Results so far prove that modelling the irrigation planning of a farm filed, based on Optimal Control Theory is a good approach, helping to save water and ensuring the hydric needs of the crop. Several improvements were made since [1], and several more are still on their way.
One of the main objectives of this project is to create a prototype for smart irrigation of a farm field. We have presented the software model that will be the base of this prototype.

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6. References

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