Universidad Nacional de Colombia

Abstract

Mechanic - Mechatronic Enginnering
Engineering Department

Ph.D. Research Proposal

Multi-Agent System Platform for Irrigation Scheduling in an Onion Cultivation

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Climate change could cause irreversible damage to terrestrial and water ecosystems and loss of potential production. The impact of climate change occurs at multiple scales (global, regional and national) and sectorial (including agriculture). The agricultural sector and its sub-sectors are increasingly showing a high level of vulnerability and impact, affecting the foundation of human survival, that is, food security. The central challenge of sustainable agriculture is to meet the food demand of the present generation without sacrificing the needs of future generations. To feed 9 billion people nutritiously by 2050 we need to make agriculture resilient, more productive in changing landscapes, reduce food waste and make use of natural resources efficiently, especially the water.

Climate change, population growth, urbanization and inadequate (excessive) management of resources, especially in irrigation; are the causes of environment degradation and gradual water scarcity to a global level. Understanding complex water resource systems in irrigation and their relationship with climatic change, is the key to the development of adaptation strategies. Adaptation refers to adjustments (response option or strategy) to moderate potential damages or to take advantage of the opportunities associated with climate change. Planned, anticipatory adaptation in irrigation districts has the potential to reduce vulnerability and realize opportunities associated with climate change effects and hazards.

Irrigation district Alto Chicamocha (Distrito de Riego y Drenaje de Gran Escala del Valle del Alto Chicamocha y Firavitoba - DRACH) was created in 1998, is located in the upper valley of Chicamocha river, and Firavitoba, wich covers ten municipalities of Boyacá department - Colombia. The gross area of the project is 11300ha and the arable area known as net area, is 7269ha, with an estimated annual volume of 240000t of onion per year. To provide an efficient service and cover the 7269ha benefited area, 6131 beneficed users and their families, the district was divided into eleven pumping stations. The units are independent, and each one is equipped with a composite system by a river structure derivation, a pump station, a pipelines network of conduction and distribution, water supply devices and predial irrigation systems. Small farms predominate, since 91% of less than 5ha, 6% between 5ha and 10ha and 2% over 10ha. In relation to land use, 78.2% of users use the ground to agriculture activity, 21% combine agricultural with livestock activities and 0.8% is devoted solely to livestock activity. The predominant model of production system is monoculture, where stands out the cultivation of onion, rotated with other vegetables, especially cabbage, broccoli, peas, spinach.

DRACH needs implement adaptation strategies of management that take into account the supply and the distribution of resources, with the prevention of scarcity in the future; taking into account the supply and demand of real water needs for onion cultivation, drainage and implementation of new technologies to manage the water resource more efficiently. On the other hand, there is a need to improve the DRACH decision supporting system, because its infrastructure was developed with supervisory control and data acquisition technology, which carry out the actions using on-off control from a central station, which consists in the switching of the controller output between a maximum and a minimum according to the requirements of the system; lacking reactive and proactive behaviors, that allow correct responses to environmental changes.

A more used approach for optimizing irrigation is the automatic irrigation controllers. Some kind of control strategies used in irrigation systems are: on-off, proportional - integral - derivative (PID), adaptive, predictive, based in neural networks and fuzzy logic models. Potential adaptation strategies to climate change include a wide array of engineering measures, improvements, or changes, including negotiating regional water - sharing agreements, integration of heterogeneous systems and enhancement the irrigation, for which the usual controllers are not efficient on their own. Due to these, implementation of a multi-agent model is useful for managing and making decisions in crop irrigation.

Many topics of complexity can be studied by a multi-agent based approach; that allows the integrated representation of hierarchies, interdependencies and behaviors of intelligent agents. A multi-agent simulation platform is proposed in this project to define the requirements and water application control on an onion cultivation context in Irrigation district Alto Chicamocha. The model will use water, plant, soil, environment, peasant knowledge and infrastructure variables, in the design and implementation of agents, organizations, institutions and norms, agents communication language, reputation mechanisms, negotiations, coordination, learning, multi-agent system and control strategies.

The aim of the model is to explore future alternatives of irrigation schedule to support and make better informed decisions about water resources management in onion cultivation. This tool will be developed take in count the challenges for mitigating and adapting irrigation resource use and management locally (plot of the peasant) and regionally (DRACH) due global climate change. A significant benefit from this adaptation research is the development of short term strategy that may link to long-term options to ensure that, at a minimum, irrigation management decisions implemented over the next one decade allow the development of abilities to bear potentially larger impacts later in this century.

Multi-agent model will be implemented using information from one of DRACH's pumping stations and its infrastructure. The project will use two components: project definition and test-integration. The first includes operation concepts, requirements and architecture, detailed design and implementation; the second includes integration, testing, verification and validation, operation and maintenance. The methodology demonstrates the relationships between each phase of lifecycle development and respective tests.