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Irrigation Scheduling in Crop Management System

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Abstract

Center pivor systems are widely used to suppress the irrigation needs of agricultural fields. In this article, we propose an autonomous to improve the low efficiency of this method of irrigation, developing a system based on the water requirement of the plantation, through field data (local temperature, local wind, soil moisture and precipitation forecast) and soil evapotranspiration calculation. The stored information will allow to calculate the real evapotranspiration, not being necessary to restrict to lysometric measures. Accordingly, it is possible to schedule the irrigation for the period in which it has the lowest cost, considering the energy produced locally and the price of energy bought in the main market. Irrigation must be carried out within the time interval in which the plantation does not reach the wilding point, so it will be carried out at the time of the lowest cost.

Keywords: agricultural irrigation, smart farming, water requirements, water resource scheduling

1. Introduction

The need for irrigation management has become relevant in many regions, specifically in Mediterranean, as result in the water resources are limited, changes in the climatic conditions and the negative effect of human behaviour on the environment.

The purpose of the irrigation is to give to plants the proper amount of water to guarantee their necessity. Requirement of water in irrigation system is very important, and the new irrigation methods should implement in such a manner that requires less water consumption when compare to old technologies. Smart irrigation means not only consuming less water it also provides water supply to optimize crop production.

For optimum yield, soil water in the crop root-zone must be maintained between desirable upper and lower limits of plant available water. Proper irrigation management will help prevent economic losses (yield quantity and quality) caused by over or underirrigation (plants should not pass the wilting point). The objective of irrigation management is to establish a proper timing and amount of irrigation for greatest effectiveness.

The measurements performed by the proposed system, in monitoring the soil moisture and the precise calculation of the evapotranspiration of the plantation have a significant advantage in terms of energy and water consumption. Real-time information on the current parameters of the system (soil moisture, evapotranspiration, precipitation) allows scheduling irrigation for the period in which it presents the lowest cost.

2. Literature Review

In this section, we first introduce central pivot irrigation systems, and then the related work is discussed.

2.1 Center-pivot systems

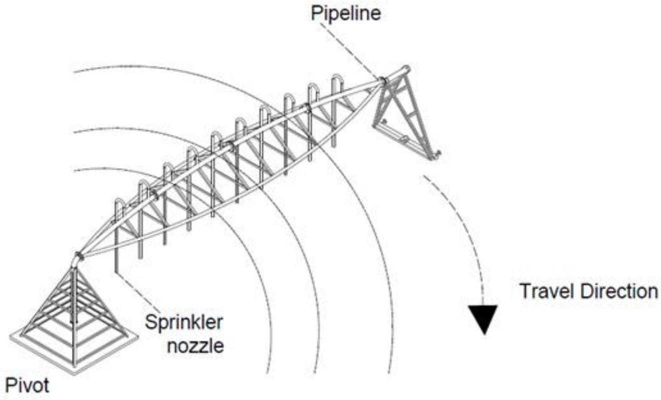

Fig. 19: Basic components of a center pivot (CP) system.

In agricultural fields, the intention to reach the maximum yield of the crop with the minimum operational costs has evolved consciously. One of the methods developed that improves the efficiency of the use of water, as well the use of energy is the irrigation by sprinkler with a system of center pivot (CP).

In Fig. 1, it is possible to visualize a CP in which equipment rotates around a pivot, in a circular path, and crops are watered with sprinklers as the machine moves [1].

2.2 Related Works

In [2], [3] a soil moisture sensor is used to water pumping the plantation when the minimum moisture level is verified, in addition [4] the system also incorporate solar photovoltaic is not only environmental friendly; it is also contribute to the improvement in power quality and enhance the reliability of the power systems [5], [6]. A Center pivot irrigation optimization to reduce the crop water necessity [7], [1] is proposed based on undergrounds sensors, and in [7] a multi depth sensors approach is tested to monitor soil. The evapotranspiration method to calculate the water requirements is proved in [8]. A approach for water irrigation scheduling is presented [9], which provides planning of the daily irrigation but not consider the minimum price of the energy bought from the main network.

The dynamic irrigation low limit method [10], which considers the parameters relates with crop growth and development time and water supply to settle the irrigation low limit. Four solutions of smart irrigation software are explained in [11], where is explored data obtained from different sensors.

3. Crop Water Necessity

To estimate the period and the adequate amount to irrigate the field, it is necessary to calculate accurately the evapotranspiration of the plantation.

The FAO Penman-Monteith method (1) is used to estimate the potential evapotranspiration (ET0) and the evapo-transpiration of the crop (ETc), which takes into account the stage of vegetative growth of the crop by weighting the potential evapotranspiration by the coefficient Kc. [8]

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)} \quad (1)$$

ET_0 reference evapotransporation [mm.day^{-1}];
R_n net radiation at the crop surface [MJ.m^{-2}.day^{-1}];
G soil heat flux density [MJ.m^{-2}.day^{-1}];
T air temperature at 2m height [ºC];
U_2 wind speed at 2m height [m.s^{-1}];
e_s actual vapour pressure[kPa];
e_a actual vapour pressure [kPa];
e_s-e_a saturation vapour pressure deficit [kPa];
Δ slope vapour pressure curve [kPa.ºC^{-1}];
γ psychrometric constant [kPa ºC^{-1}].

The calculation of ETc (2) is the product of ET0 and Kc, where kc is determined from the type, growth length of the crop and selects the corresponding coefficients Kc.

$$\boldsymbol{ET_c = ET_0 * K_c} \quad (2)$$

ET_c crop evapotransporation [mm.day^{-1}];
ET_0 reference evapotransporation [mm.day^{-1}];
K_c single crop coefficient.

4. Proposed system

The circular irrigation infrastructure demonstrated in Fig. 2, introduces multiple zones of the agricultural field, in which we can have different plantations or plants of the same type but in different stages of growth. The system considers the irrigation need for each zone and acts on the speed of the infrastructure motor and valve motor of the water pumping, if it is necessary to irrigate the area in which the infrastructure is located.

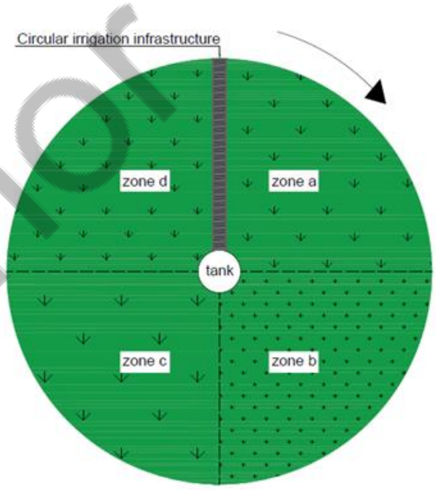

Fig. 20: The areas considered (a, b, c and d) may have distinct plantations.

It is calculated how many hours are left until the level of soil moisture is below the limit established for the plantation of the different zones, considering the evapotranspiration of each zone and the precipitation forecast.

In this way it is possible to obtain a daily schedule of irrigation for a given area considering the local energy production, the market price of energy and the restrictions of the logistic operation, in order to optimize the use of water and minimize the cost of energy purchased from the main market.

5. Conclusions

Real-time monitoring of agriculture has become indispensable and is a tool for obtaining data that are important for the development of energy efficiency systems. Therefore, the present methodology intends to take advantage of this information not only to minimize the use of water, but also to minimize the energy cost of the irrigation system's electrical installation.

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