

# Monitoring System for Agrometeorological Application with Voice-Controlled Interface

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**Abstract**—The objective of this work is to present aspects about the already completed development stages of a monitoring system for agrometeorological application that uses Human-Computer Interface controlled by written and spoken languages. Technologies related to the development of this type of HCI have been increasingly used and are gradually more connected to the most diverse devices and machines including fieldwork uses. This interdisciplinary work is supported by research in the areas of Meteorology, Linguistics, Natural Language Processing (NLP) and Computing using physical prototypes focused on monitoring: automated solar search, unmanned aerial vehicle (UAV), unmanned groundvehicle (UGV), mix of meteorological sensors and the system itself. The steps already completed and interrelated - automated solar tracker, the set of meteorological sensors and the system - show that this type of monitoring has a significant degree of accuracy, low cost and autonomy - it does not depend on the conventional grid and makes small decisions.

**Keywords**—Unmanned Vehicles, Digital Agriculture, Severe Weather, Linguistic, Agriculture Applications

## I. INTRODUCTION

In general, monitoring systems have become more common as technologies improves. Among them, there are those for agrometeorological application, which are quite useful when it comes to improving productivity and automation [1]. In this context, the objective of this work is to present some of the aspects related to the development stages already completed of a monitoring

system for agrometeorological application using Human-Computer Interface (HCI) controlled by written and spoken languages.

Technologies related to the development of this type of HCI have been increasingly used and are gradually more connected to the most diverse devices and machines including fieldwork uses [2, 3]. Therefore, the development of this monitoring system, has given opportunities to research works already developed in Brazil and has expanded the applicability of the automatic recognition of written and spoken texts for a greater variety of uses in the Portuguese-Brazilian language [4]. The applicabilities, including a photovoltaic automated solar tracker, a set of meteorological sensors and the system, are numerous: home automation, virtual robots for decision making, some functions in automobiles, elevators and games [5].

About technological innovations in agrometeorology, new tools are important for countries like Brazil. One of the main problems in the agriculture, mainly for the agricultural exportation items, is the meteorological extreme events. There are countless losses, both material and economical, in the history of Brazilian agriculture [6]. Extreme events may worsen in the country due to the effects of climate change [7]. Although hail is a well known extreme event, its study is innovative in Brazil. This is due to the fact that it is a highly local phenomenon of short duration. Therefore, it is extremely complicated to use an equipment to measure hail, mainly for the study of the formation of rocks in the clouds.

The development of this type of technology allows the obtainment of other advantages such as maintenance of interdisciplinarity, integration of other Units and educational institutions, greater proximity to Institution-Companies through junior companies or startups; and the motivation of users and companies on the use/industrialization of products generated among others.

## II. METHODOLOGIES

This interdisciplinary work is widely supported in research in the major areas of Meteorology, Natural Language Processing (NLP), Linguistics and Computing. The application of the research has been done directly in physical prototypes that, operating together, allow the agrometeorological monitoring.

The complete monitoring system will have at least five operational blocks: automated solar tracker, unmanned aerial vehicle (UAV), unmanned ground vehicle (UGV) coupled with a UAV recharger by electromagnetic induction, a set of meteorological sensors and a system with chat robot.

The steps already completed and inter-linked through the system are the automated solar tracker, the set of meteorological sensors and the mobile system itself. Each of these elements, which belonged to a separate project, were being integrated to each other as the needs for agrometeorological application became more complex.

## III. FINALIZED AND OPERATIONAL STAGES

The automated solar tracker (hereinafter *Solar* prototype) as shown in Figure 1 was the first physical prototype used for HCI implementation and testing for agrometeorological monitoring. Its basic software for monitoring physical quantities (ex. voltage, electric current and power, solar radiation, relative humidity, ambient temperature, wind speed and others) are finalized and controlled by voice and written text through a robot called *Solar robot* [8,9].



Fig. 1: Operational Automated Solar Tracker.

This automated solar tracker originally belonged to an interdisciplinary and interinstitutional project called S.O.L.A.R (in portuguese *Sistema de Orientação Latitude-longitudinal Automático Regenerativo*) - Automatic Regenerative Latitude-longitudinal Orientation System1 (hereafter Solar only). The basic function of the Solar project is the capture of solar energy through photovoltaic panels that follow the movement of the sun throughout the day with a microcontrolled mechanical solar tracker. The energy is stored in batteries and the process is monitored and controlled for better energy management. This prototype is responsible for the autonomy of the agrometeorological monitoring system, since it is done regardless of any conventional power grid.



Fig. 2: Basic interface of the solar robot.

The Solar robot (Figure 2) is a chat robot, which responds to commands by voice and voice synthesis. It has been

programmed in C# language, uses the *Coruja* as a recognizer [10] and uses *Loquendo* [11] to 'talk'. The word search system is done through hash tables [12, 13]. The robot responds very efficiently to commands in Brazilian Portuguese, returns in an essentially Brazilian language registry and presents a reduced rate of speech recognition failures. The block representation of the system integration used in the robot can be seen in Figure 3.

It is important to point out that the Solar robot is based on another existing robot called Tical - Interactive Conversational Technology on Language Matters [14-17], which is used for research in the area of Linguistics, specifically data of the Linguistic Atlas of Brazil – ALiB [18, 19] and the Historical Lexicon of Paraná – LhisPAR [20]. However, despite having similar resources and search techniques for synonyms and programming languages used, their respective applications are quite diverse: Tical is used for linguistic research; Solar is used for the management of photovoltaic energy.

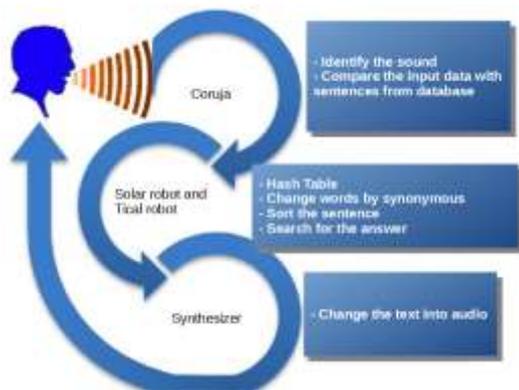


Fig. 3: Solar robot functionality.

From the usability and accessibility point of view of [21], once started, the Solar robot optimizes the queries because it is not necessary to use conventional data entry devices like keyboard and mouse to have access to the data. In other words, it eliminates the acts of typing or clicking buttons while managing photovoltaic resources. It is worth remembering that although all access can be done with voice commands, of course there is, a visual interface of the system (Figure 4) from which the user/operator can observe data and information concomitantly and, if necessary or preferable, the robot also responds by written text.

Table 1 presents a basic list of the commands that are answered by the robot. In this table, there are the subdivided quantities that are monitored, eventual linguistic variants, the unit of measure of reference and the expression used by the robot to answer by voice synthesis. The user/operator when asked by voice "panel voltage" - item 1 in Table 1 - has voice response "panel voltage 'x' volts". If the battery is 12.8 volts, the response

of the robot will be "panel voltage twelve-volt comma eight". The same question can be asked using the keyboard in the field for the written text.



Fig. 4: Monitoring system interface by the Solar-Sima project

Tab. 1: Basic information of Solar robot.

	Variable	Linguistic variants	Answers	
			Unit	Syntax
1	<b>Panel Voltage</b>	Panel Volts, Voltage Panel	V	Panel Voltage 'X' Volts
2	<b>System Voltage</b>	System Volts	V	System voltage 'X' Volts
3	<b>Power System</b>	Watts of System	W	System power in 'X' Watts
4	<b>Power Panel</b>	Panel watts, Power board	W	Generating 'X' Watts
5	<b>Solar radiation</b>	Sun, Light intensity	W/m <sup>2</sup>	'X' Watts per square meter
6	<b>Wind speed</b>	Wind velocity, Wind	m/s	'X' meters per second
7	<b>Temperature</b>	Degrees, weather	°C	'X' Celsius degrees
8	<b>Air Humidity</b>	Humidity	%	Air Humidity in 'X' percents
9	<b>Precipitation</b>	rain	mm	'X' millimeters
10	<b>Air Pressure</b>	Pressure	bar	'X' bars

The management of photovoltaic energy made possible by the HCI developed here, however, generated the need to monitor other physical quantities besides those specifically electric, such as voltage, current and/or power. The meteorological conditions influence directly on the generation of photovoltaic energy [22] and other

decisions can be taken, both by the user / operator and by the programmable routines themselves in the system. For this reason, the main screen of the second version of the HCI (Figure 4) already predicted the magnitudes related to atmospheric measurements such as wind speed, relative air humidity, solar radiation, among others.

The prototype Solar then incorporated another prototype called SIMA (*Sistema de Informações e Monitoramento Atmosférico*, in portuguese - literal translation: Monitoring and Atmospheric Information System; henceforth only Sima) and evolved to what is now called the Solar-Sima Prototype (Figure 5). This new set is able to generate metadata, that, means data of which it benefits itself, since it is possible to predict the generation of photovoltaic energy [22] from annual meteorological data, for example.



Fig. 5: Integrated Solar and Sima prototypes and in operation.

Sima added to Solar the ability to monitor physical quantities relative to meteorology such as solar radiation, relative humidity, ambient temperature, atmospheric pressure and wind speed. Since then, some findings regarding local weather conditions - Fatec Garça campus - could be verified. Among them there is a daily overview of available solar radiation shown in Figure 6 and essential to the management of photovoltaic energy.

In Figure 6, the surrounded fields highlight moments in which clouds partially obscured sunlight throughout the day and the field highlighted by the square shows the gradual fall of typical twilight solar radiation. Another possible monitoring is to observe the latitudinal and longitudinal tracings of the sun throughout the day through a graph (Figure 7). This measurement, although it is more associated to astronomical aspects than necessarily meteorological, it will allow the equipment to collect accurate data on useful angulation of the rays of the sun respecting the photovoltaic effect. After the data collection, these data can be crossed in certain periods and present, among other information, optimal conditions

for solar energy management through consultation with the Solar robot.



Fig. 6: Solar-Sima interface indicating the solar radiation in a specific day.



Fig. 7: Interface indicating latitude and longitude position of the sun in a specific day.

The HCI developed for the Solar-Sima monitoring system will help with the collection of data for a series of applications, whether for industrial use or applied to productive sectors. Among them was the integration of Solar-Sima to the Fapesp Project recently approved by Fatec Garça, in which IHC will help to better understand the formation of hail and to study its impact in a coffee production in the region of Garça. The UAV will be responsible for releasing appropriate sensors for this type of cloud and the sensor data will be sent to a data center with software that will treat them for further study. Figure 8 shows an overview of the Garça FAPESP Project, for which the programming proposed here is essential.

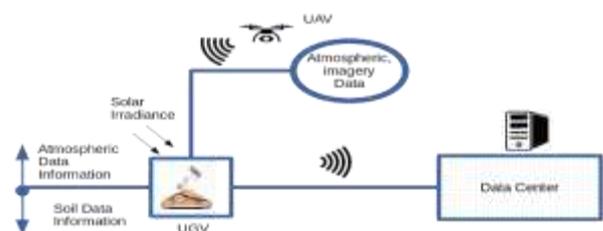


Fig. 8: General overview of the main project based on this work.

#### IV. CONCLUSION

This work presented preliminary results of a technological innovation project in the environmental area, which shows an automatic agrometeorological data station with a voice command system. The results demonstrate an advance in the area of meteorology and IHC. The latter demonstrates the effectiveness of a chatbot developed for the Brazilian-Portuguese language.

Some tests were performed using a low-cost meteorological station powered by a solar tracker. All information on the panel's meteorological and electrical variables was tested and performed successfully.

The results presented in this work are an integral part of a project to study the formation of hail in the state of São Paulo, Brazil. The contributions obtained here will have primordial importance for the continuity of the project, integrating computational systems with large volume storage of surface and atmospheric data.

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