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SOLAR-POWERED UAV PLATFORM SYSTEM: A CASE STUDY FOR GROUND CHANGE DETECTION

Ramos, A.C.B.[I]; Santiago, M.S.[I]; Shiguemori, E. H.[II]; Serokhvostov, S.[III]; Gupta, P.K.[IV] and Zhong, L. [V]
***UNIFEI[I], IEAV[II],MIPT[III], JUIT[IV] and CAUC[V]**
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Abstract

This paper aims to present some of UAV, Communication, IT and High Performance Computing tools in Geospatial Technology area. Important research topics in the area are the detection of changes in multiple images of a soil region to security, deforestation identification and changes in plantations, river courses, shorelines and glaciers. Students, teachers and researchers from four BRIC countries: Brazil, Russia, India and China are conducting joint research in low-cost systems involving unmanned aircraft powered by solar energy (Russian team), communication systems over long distances (Chinese team), change detection algorithms in the soil (Brazilian team) and distributed systems based cloud for identification of the type of change detected (Indian team). Some intermediate results are presented.

1 Introduction

This paper presents an International Cooperation Project aimed at joining efforts of research groups of BRICS countries countries (Brazil, Russia, India and China) to develop Unmanned Aerial Vehicles – UAV (or Remotely Piloted Aircraft - RPA) solar-powered, equipped with electronic systems to ensure, precisely, its position and trajectory control and collect ground images to be transmitted to a ground control station for cloud storage and subsequent digital processing.

Currently capturing images of the earth is gaining great importance, in particular for ground change analysis for several purposes, such as geospatial studies, fires, natural disasters, agriculture etc. In most cases images are needed not only of a region but images of huge tracts of land, such as forests, large farms etc. In this case it is necessary to comply with a wide range of requirements. In order to cheapen the process of acquiring photos, satellite photos can be replaced by photos taken from sensors installed in UAV, which uses technology that allows its flight practically in autonomous way.

2 Objectives

The Russian researchers team are responsible for the specification, design, construction of the RPA solar energy-powered, since the strong team point is the deep knowledge from RPAs aerodynamic research and the field of design electric engines for this type of aircraft, combined with research on solar receiver systems as well as extensive experience in the design, manufacture, piloting and tests of RPAs. Also, studies about the peculiarities of the airflow around the wing as well as the stability and control of aircraft designed . These skills can be proven by the results published in the articles referenced at the end of this paper [1-4].

The role of Brazilian researchers involves the analysis, design, implementation, testing and integration of Artificial Neural Network - ANN algorithms to identify deviations in the trajectory of the RPA and the resulting chain of command necessary for the aircraft route correction. In this context Brazilian team has several works developed [5-12] including in partnership with the China team of researchers. The Brazilian team will also do joint studies related to flight dynamics of the aircraft built by the Russian team.

The team of researchers from India develop studies related to Artificial Intelligence

applied to identify the type of change occurred in the soil from images and videos provided by sensors embedded in the RPA. They will also develop studies related to Data Mining regarding the captured images as well as studies in the Human Computer Interface related to the presentation of information to system users. Some knowledge of the team members in relation to the tasks mentioned, can be seen in publications referenced at the end of the text [24-26] .

The problem related to long distance communication is addressed by the China team of researchers whose strong point is the knowledge in the application and implementation of signal processing algorithms design and test, construction and communication systems. Since 2010, Chinese team has implemented various devices, for example air-ground voice communication system with a noise interference suppression system, as well as GPS receivers. Some studies conducted by the Chinese team are referenced at the end of this text [13-23].

3 Intermediate Results

Due to its dimensions, UAV fixed-wing electrical aircraft are very susceptible to atmospheric disturbances and also have smaller flight range. Thus, to obtain good pictures, it is necessary to find good flight plans and aircraft parameters. In particular, to optimize stability and autonomy the aircraft's shape should be optimized. In particular a wing whose shape leads to different types of flow and the specific Reynolds number, see fig. 01.

To extend the endurance and range, the Russian researchers of this project, led by Prof. Dr. Sergey S. Serokhvostov of the Moscow Institute of Physics and Technology - MIPT, have studied various strategies [01-04], two of the most promising are: a) the use of solar cells on the upper surface of the wing, which influences in various problems due to the physical and mechanical properties of solar cells that can cause deformations and change the wing shape; and b) use special surfaces with the changing orientation.

Figure 01 – An UAV solar powered prototype.
Source: Authors.

Despite its limitations the use of UAV, powered by electric motors, is quite growing about to become indispensable in many applications where human intervention is dull, dangerous, risky or expensive, for example border surveillance, forests monitoring, inspection of large plantations or extensive electric transmission lines among others.

Due to its vast territorial area Brazil, Russia, India and China are among the seven largest countries in the world, for these countries to border surveillance, for example, it becomes a major problem whose solution can be supported from the use of UAV using navigation based on the Global Positioning System - GPS.

However there may be problems with the use of GPS derived instrument defects, or antennas, or problems as the South Atlantic Anomaly - SAA, a change in the Earth's magnetic field which can jeopardize the UAV autonomous navigation. In this context several works evolving UAV [05-12], have been conducted by Brazilian researchers coordinated by Prof. Dr. Alexandre C.B. Ramos at the Federal University of Itajubá - UNIFEI, to develop more accurate navigation systems using ground images recognition. Georeferenced images (provided by satellite or by UAV in previous flights) are compared with images collected by the UAV in real-time. This comparison allows the subsequent UAV localization and trajectory correction, see fig. 02.

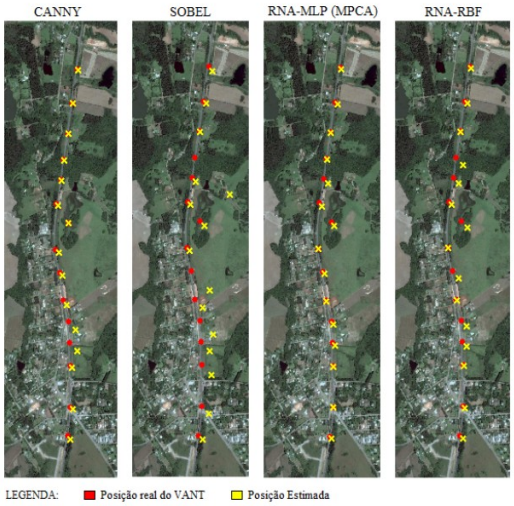

Figure 02 – Different techniques for UAV estimated position (yellow) and real position (red).
Source: Authors.

Currently, most of the image transmission systems for UAV employs Line of Sight – LOS communication or wireless mobile networks. The effective distance of LOS communication is limited. The relaying mobile communication is limited by the position of the base station, also the transmission quality of mobile communication is problematic because the signal intensity around the base station is randomly changed. To ensure the working distance and quality of transmitted images, Chinese researchers coordinated by Prof. Dr. Wu Renbiao Civil Aviation University of China - CAUC, are working on developing a long-range communication system [13-23], see fig. 03.

Considering the long-range and robustness coverage requirements on the quality of communication signal, the satellite communication becomes a good option, to ensure low power dissipation, light weight and small size of the external communication terminal. This external communication terminal can be used in embedded systems with board communication terminals and earth.

Different information will be transmitted via the communication system, for example, ground images, the UAV control commands, movies from camcorder to the ground station, the UAV telemetry, trajectory correction commands for both is currently a communication protocol. Taking into account real-time transmission and communication bandwidth limitation, a video compression system is being implemented to be embedded in the UAV and a decompression system is designed to operate in at ground control station.

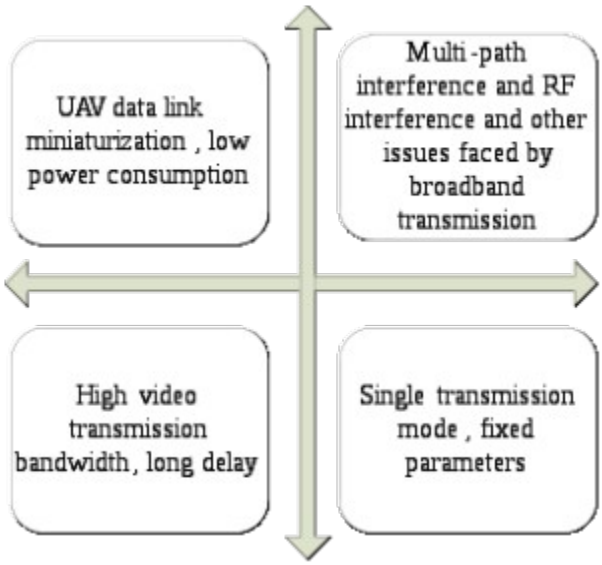

Figure 03 – Existing problems for UAV datalink.
Source: Authors.

Humans are promoting an accelerated modification of the earth's landscape, these changes lead even the climate changes that are profoundly altering the Earth surface processes, creating ecological challenges. It is expected that the environmental impacts of human activities that can cause an increase in temperature will keep growing and generating global warming. A key example to recognize the degree of destruction is the ground erosion. Soil erosion is a natural process , but it has been greatly accelerated due to deforestation, cultivation and wrong land use practices.

Incidents such as drought, pests, forest fires, melting ice caps, displacement of coastal lines and change of riverbeds are now reported worldwide every day. In this context, the Indian researchers coordinated by Prof. Dr. Pradeep K. Gupta of Jaypee University of Information Technology [24-26] propose the development of machine learning algorithms based on computational cloud to perform geospatial image comparisons captured by UAV to identify changes in the patterns in Earth structure, see fig. 4.

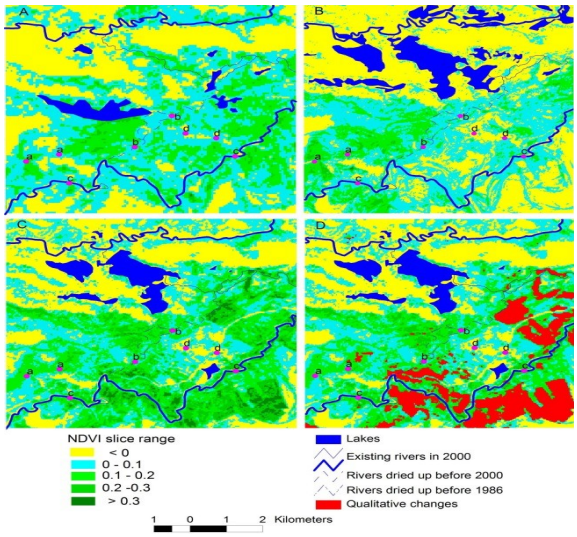

Figure 04 – Colored maps to change detection.
Source: Authors.

The system under study also help identify and track the pollutants moving waterways, such as canals, rivers and oceans. Initially the algorithm will identify changes in the Earth's structure (rivers, forests, farms, glaciers, etc.) using digital image processing and then predict the extent of the changes in the next months and years using a machine learning algorithm.

4 Metodology

Once the model is complete, it will be deployed as a cloud service that will allow users to get results and share their findings on a common platform. Among the various sub-areas of Geosciences, this research project focus on important issues and are currently in discussion with the scientific communities, namely:

1. A solar powered UAV;
2. Trajectory control from the pattern matching with known images;
3. Detection of changes in the environment from the ground pictures patterns ;
4. Detection of pests in crops;
5. Monitoring changes in coastlines, rivers and lakes;
6. Automatic control of UAV trajectories.

The approach of the subareas above, allows developing research projects focusing on different areas of human knowledge that are integrated to solve the problems addressed by the different project teams .

In order to obtain satisfactory results, it is necessary the interaction with researchers who have prior knowledge of the described sub-areas and are conducting advanced research in this area and are willing to join efforts. In this context it is carried out several work missions among team members initially to set goals, in a second time for monitoring and assessing the work carried out during the 36 months of the project duration and finally the project completion meetings. In addition to mission work among teachers/researchers/students there will be also four study visits of 30 days abroad so that members of the teams might interact more strongly.

With the development of this work we can see great opportunities for both the members of the Brazilian team and for members of foreign teams, for example, the Brazilian team: a) allowing students attending training courses that are not offered by UNIFEI b) Realization of stages of 30 days for graduate students, c) Conducting Postdoctoral stages during 30 days, d) Interaction with members of foreign teams in the laboratories of foreign universities, e) scientific publications in journals/international conferences, f) Opportunity to improve foreign language and to insert into another culture. In terms of activities and opportunities for foreign researchers are: a) allowing researchers to take courses/training seminars that are offered by the Graduate UNIFEI programs, b) perform numerical simulations and experimental tests using UNIFEI laboratory, c) realization PhD stage, d) Postdoctoral training and) short visits to develop or learn new techniques and apply them to the project sub-areas, f) scientific publications in journals/international conferences) Opportunity to improve foreign language and enter in our culture.

In the academic area the integration and cooperation favored by the internationalization of the institutions involved in the project process will bring great benefits to Graduate programs of the different countries that will allow teachers and foreign researchers to teach courses and conduct joint researches. This

process will increase the quality of work done in the context of contributing with Graduate programs for the development of scientific technology parks of different countries.

In the industrial area, there are great prospects in the realization of products and services favored by this project especially, in Brazil, with the Airbus Helicopters Company, the only one helicopters factory in the southern hemisphere, leading member an aeronautical park in the city of Itajubá (MG) which is headquartered UNIFEI. The development of trajectories of control algorithms, digital algorithm processing and solar powered aircraft are certainly of interest from Airbus Helicopters which has been developing joint projects with members of the Brazilian team.

5 Results

Reference to the products and results are seen in Item 6. Schedules can show that this joint research project has four main results:

1. The development of a RPAS, low cost, driven by an electric motor provided with a solar cell system, with payload of approximately 10 kg, and cameras with electronic systems that operate in the visual spectrum (and may also operate in infra-red spectrum).

2. The development of a software system that allows the identification of differences between RPA x Satellite photos and images to identify changes, such as plagues, invasions, deforestation, etc.

3. Developing a cloud-based system for distributed capture and identification of anomalies made by man, such as deforestation, fires, changes in river courses and changes in coastal and glaciers.

4. The development of a signal processing system for long distance communication, provided with specific antennae systems, electronic, mechanical and computer algorithms in communication protocols.

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Contact Author Email Address

mailto: ramos@unifei.edu.br

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