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Seed Plant Drone for Reforestation

ERICO PINHEIRO FORTES

Introduction

An important point about changes in society that should not be ignored is that technological evolution reflects the progress of our own life styles. The usage and applicability of drones has been considerably growing since the 20th century through now (1). In this project, we decided to introduce this robot in the agriculture, deserted and deforested fields.

The purpose of the project is to develop a motor controlled autonomous flying vehicle that is capable of dispersing seeds in agriculture fields with potential for reforestation. This work includes three components: a custom-build quadcopter; a computer-controlled seed dispenser; and software that can generate GPS coordinates for mission trajectory, control the seed dispenser, and communicate with the operator(s).

This autonomous quadcopter is equipped with a GPS navigation mechanism controlled by an operator. Once the coordinates are received, an operation area is defined. The software is developed to receive the GPS coordinates for the selected area (target field), plot out a flight trajectory, and traverse/navigate the entire area. An Arduino, which is placed on the quadcopter, runs this software, providing telemetry communication to a ground station and control in the seed dispenser. In addition, this craft possesses a radio-controlled mechanism that allows the operator to take over control as a failsafe.

The seed dispersal mechanism is a container for storing seeds and a motor-controlled mechanism for releasing them. This motor device is designed to precisely regulate the flow at which the seeds are released. The seed dispersing software running on the Arduino drives the motor proportionally to the velocity of the aircraft so that the seeds are precisely released at the desired location. The seed container is built to fit the quadcopter and be durable in case of collisions.

Background

Recognizing the challenges faced by many countries in development, we must also be able to take the opportunities to use novel technologies. This idea of drone and seed dispense for reforestation and restoration has a high demand in the field of science and nature. Not discussing the issue of global warming, we have come to notice drastic changes in temperature and natural pressures in forests and other ecosystems all around the globe. Hence, the idea of a seed planting from a pilotless aircraft vehicle to solve problems of desertification in these ecosystems. I believe it will definitely set new trends in science and ecology. Projects of the same nature can also bring a new perspective that may drive people's ideas of science vs. nature towards a positive outlook. We need to break misconceptions and operate high-end technologies to help communities and countries grow towards development.

A quadcopter is known as a multirotor and an aerial vehicle characterized to possess four arms in which each has a small motor with two pairs of fixed pitch propellers installed (2) as we can see on Figure 5. With one pair spinning clockwise (CW) and the other pair spinning counter-clockwise (CCW), both motors are operating in opposite directions to generate the turning force or torque to help it lift and thrust (2).

Formally known as Unmanned Aerial Vehicles (UAV), drones are flying robots that use GPS navigation and software-controlled flight, also installed in their flight controller systems (flight controller board), capable to perform autonomous flight operations (3). A quadcopter is referred as a type of drone if it can fly on its own and also use a GPS navigation system. Many people do not know the correct distinction between drone and Quadcopter and think that all quadcopters are drones. Especially, in commercial markets, they may be treated as drones, which may lead to controversial disputes and misconceptions (4). In this research, the built quadcopter will be treated as a drone because it satisfies the requirements to be treated as such.

These days, drones are being used in diverse ways, from the simplest such as taking high-altitude pictures and videos to more complex tasks such as military operations. Since they are quite versatile once properly programmed, they can perform a great deal for the ecological balance of the planet.

Related Work

Due to their versatility and cost effectiveness, drones are becoming strong allies in fighting against environmental issues and controversies such as crop inspection and survey work for the inspection of flood defenses (5). Based on these facts, companies, profit and non-profit institutions, and singular entities are trying to develop projects that can take on the responsibilities and benefits that the UAVs have to offer. Ambitiously, this may significantly impact a change on the disputes and misconceptions on climate change.

Although there is technically only one of many most finished works on seed-dispensing aircraft models, the literature review on this work will focus on studies that use drones on agricultural fields. Most other projects focus on creating technological innovations that can potentially decrease or contribute to the global health of forests and reforestation tactics.

Bio-Carbon Engineering Project

This project, funded by an ex-NASA engineer Lauren Fletcher and his team, recognizes that this emerging technology (drones), combined with remote sensing and machine learning, solves the industrial scale deforestation (6). Based on its precision, efficiency for data collection, analysis, mapping, and planting, Fletcher believes that the restauration of many ecosystems can be feasible (6).

This project's objective is to plant one billion trees a year. First, a drone hovers two to three meters above the selected area to identify and report the potentiality for reforestation. Second, following a pre-determined pattern, these drones carry these pre-germinated seeds and plot them into the soil (7). The seed dispenser mechanism is small, pressurized canisters that provides enough force so that the seed can penetrate the soil surface and eventually grow overtime (7).

These drones can plant 10 seeds per minute and be controlled by two operators having multiple drones operating at the same time. This work is able to plant approximately 3,600 seeds in one day. (8).

Drone Forestry – UAV – RPAS

This project was developed by the Spanish company Novadrone that aimed to create a commercial solution for forest management in order to maintain the health of the forests around the world using the help of aircraft vehicles (9). The application of this project in the area of reforestation greatly served much as a supportive tool for forest managers, focusing on the following aspects (9):

- Improved forest management and operational planning
- Inventory assessment for valuation and taxation
- Monitoring of illegal activities and violation such as recording
- Research on health of forests, enabling targeted responses
- Rapid response to environmental impact events, e.g. assess storm damage

The mode of operation of drones developed by this company was divided into three main focus points:

- Plan – a potential area for reforestation will be selected while a survey is used to analyze the soil, then simulations, mapping missions, and tasks will be consequently created to generate a net data (9);
- Fly – in a fully autonomous mission, the drone will take off, and high-resolution images about the area will be registered. After recognizing the mission, the drone will land autonomously once the task is completed (9);
- Process - collected information will be processed in order to have more accurate and precise performances based on all the collected data and deliver results to their customers.

Methodology

Software

Mission Planner

Mission Planner is a full-featured ground station application for the ArduPilot open source autopilot. This community-supported application was developed by Michael Oborne (18). This free software designed for mission planning on Unmanned Aerial Vehicles (UAV) includes the following features [mission planner help]:

- Flight Data - Primary flying screen with location and attitude
- Flight Planner - Plans your flight and other scripted actions
- Configuration - Customizes the PIDS and other

Figure 1- Mission Planner (Mandatory Set-Up)

Figure 2- Generated Coordinates File

```
QGC WPL 110
0	1	0	16	0	0	0	0	41.991100	-70.960339	26.000000	1
1	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.961105	20.000000	1
2	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.961204	20.000000	1
3	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.961303	20.000000	1
4	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.961402	20.000000	1
5	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.961502	20.000000	1
6	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.961601	20.000000	1
7	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.961700	20.000000	1
8	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.961799	20.000000	1
9	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.961898	20.000000	1
10	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.961997	20.000000	1
11	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991001	-70.962097	20.000000	1
12	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991100	-70.962097	20.000000	1
13	0	0	16	0.000000	0.000000	0.000000	0.000000	41.991100	-70.961997	20.000000	1
```

critical settings, including enabling and disabling hardware

• Simulation - Used with Xplanes and Flightgear for HIL simulation when used with your board

• Firmware - Updates your APM Firmware with the latest stable built-in and sets up your new ArduPlane/ArduCopter/ArduRover.

• Terminal - Manual set up of your APM that runs tests on sensors, log readings, and other functions.

Figure 3- Mission Way Points

Figure 4- Seed Control (Arduino Examples)

```
int LED = 13; // Use the onboard Uno LED
int isObstaclePin = 7;  // This is our input pin
int isObstacle = HIGH;  // HIGH MEANS NO OBSTACLE

void setup() {
  pinMode(LED, OUTPUT);
  pinMode(isObstaclePin, INPUT);
  Serial.begin(9600);
}

void loop() {
  isObstacle = digitalRead(isObstaclePin);
  if (isObstacle == LOW)
  {
    Serial.println("Dispensing...");
    digitalWrite(LED, HIGH);
  }
  else
  {
    Serial.println("No Seed");
    digitalWrite(LED, LOW);
  }
  delay(170);
}
```

The operator uses this software to setup mandatory configurations (initial setup) on the Pixfalcon micro px4 autopilot, indicated in the red box on Figure 1. The software is also used for motoring the state of the quadcopter before, during, and after the mission.

GPS Coordinates Generator

This software runs in an Arduino and basically receives input from the operator and computes the data and "design" of the mission path, the flight patterning, and the plotting plan.

Seed Control

The seed control code uses an infrared sensor (obstacle detection sensor) that monitors the seed releasing process by providing information to the

Table 1- Material/Hardware Needed

Material / Hardware	Price	Online Store
A2212/13T 1000Kv	$ 29.99	www.amazon.com
4 Pcs ESC Simonk	$22.35	www.amazon.com
2x 3 cell Battery Power 2100ma	$38.00	www.amazon.com
Quadcopter Frame	$27.99	www.amazon.com
PixFalcon Micro PX4 Autopilot plus Micro M8N GPS and Mega PBD Power Module	$146.00	www.hobbyking.com
Arduino UNO R3 ATmega328P	$9.29	www.amazon.com
Spektrum 6630 DX6i 6CH DSMX Radio System with AR610 Receiver	$159.99	www.amazon.com
9" Propeller Props Blades Guards	$15.98	www.amazon.com
Phantom YoYo SD/MICRO-SD CARD BEAKOUT MODULE	$6.70	www.amazon.com
3DR Radio Telemetry (xbee + usb adapter)	$27.89	www.amazon.com
2x Propeller counter rotation 2 pairs	$24.00	www.amazon.com
Lock & Lock 4pcs	$13.70	www.amazon.com
3.5mm Male Female Banana Plug Bullet Connector Replacements	$5.40	www.amazon.com
C2G / Cables To Go 43036 4-Inch Cable Ties	$2.00	www.amazon.com
Screw m2.5x5mm	$10.99	www.amazon.com
Screw M2.5x8mm	$5.46	www.amazon.com
Screw M2.5x20mm	$8.17	www.amazon.com
PPM Encoder	$10.69	www.amazon.com
Total	$564.59	

Figure 5- Quadcopter (All Perspectives)

operator. The operator will then know if seeds are being properly dispensed or not.

Hardware

To develop this project, some materials/hardware were used to assemble the Seed Plant Drone System as it is shown on the table on the next page:

Quadcopter/Drone

The quadcopter was built using a frame for a multirotor, more specifically a quadcopter, where all the structure of the UAV is mounted. This quadcopter is powered by a battery connected to a power module responsible for distributing the power to the four output channels. The output connections provide five volts each, and they are connected to four ESCs, all connected to the four motors. The drone has an Autopilot Flight Control Board as the central unit that receives the commands from a Radio Control System and uses a GPS system for navigation. Using a PPM (Pulse-Position Modulation) encoder, signals from the receiver are received in the central unit for desired operations. Then

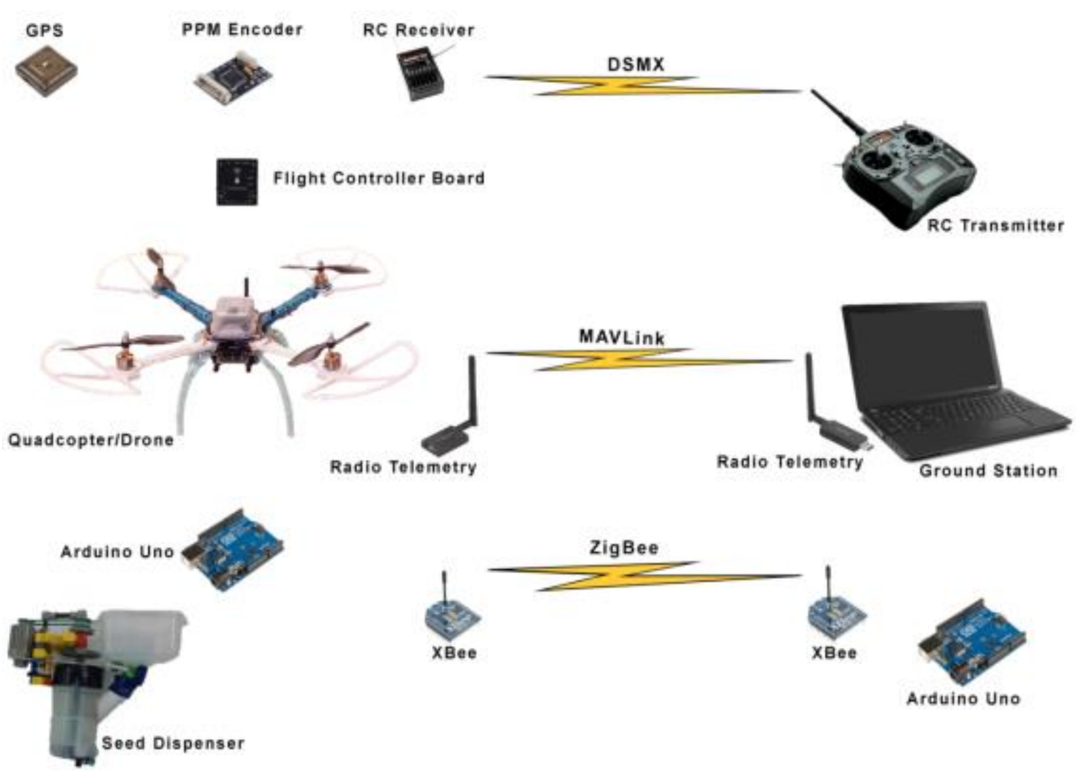
Figure 6- Seed Dispenser Mechanism

the commands sent from the radio-control system are managed by DSMX protocol. The ground station uses a telemetry radio system over the MavLink protocol to get the information from the Autopilot Flight Control Board.

The main hardware components used to build and control the quadcopter are:

- Air frame: Vktech® S500 500 mm FPV Glass Fiber Four Axis
- Auto pilot: pixfalcon micro px4
- Radio control: Spektrum 6630 DX6i, 6 channels DSMX Radio System with AR610 Receiver
- Telemetry: Hobby-Ace 3DR Radio Telemetry Kit

Figure 7- Seed Plant Drone System



915Mhz Module
• On board sensor: Neo M8N GPS Module
• Power module: PixFalcon PDB
• ESC: Andoer 4Pcs Simonk 30AMP 30A SimonK Firmware Brushless ESC w/ 3A 5V BEC
• Motor: Andoer A2212/13T 1000KV Brushless Motor
• Propeller: 2 pairs 1045 10*4.5 Propellers
• Battery: Venom 20C 3S 2100mAh 11.1V LiPo

Seed Dispenser

The seed dispenser mechanism's main role is to release the seeds on the selected site. The seed-releasing course is controlled by a Lego DC motor, connected to a 5V power supply. Seeds are dropped inside the container and sequentially dropped into a rotational dispensing compartment through the holes into the bottom of that container. At the bottom of the container, there is an infrared sensor that is able to detect the presence or absence of seeds being dispensed by the motor dispenser. Figure 6 shows the seed dispenser mechanism and the main components.

First, the operator should know in advance the exact location that has been target by the aircraft using a seed plant drone. This can be done by relying on pictures, videos, or satellite-scanned images as analyzed data. Based on this information, the operator defines the area to which it will be operating.

Second, the operator then uses the software to generate the necessary waypoints (mission path) by typing as input the initial waypoint and the final waypoint with the corresponding latitude and longitude and the distance between waypoints as well. The software translates these inputs by generating coordinates as a rectangular area with successive waypoints, and the mission path is defined as we can see on Figure 3.

Third, the GPS takes the current position of the quadcopter as the waypoint that represents Home. This waypoint will serve as the "TAKEOFF" position before the mission is performed and returned to launch position after the mission is completed.

Last, the coordinates stored in a SD card, inserted in a SD card module, connected to the Arduino are ready to be uploaded remotely on the Mission Planner software to the Pixfalcon Autopilot by using FPV telemetry radios. The Arduino on the ground station is connected to other Arduinos placed on the quadcopter by using XBee's radios to communicate with each other; it means that a replica of data-write by one of them will appear on the other and vice-versa. Once properly connected and functional, they transcribe all data using serial communication.

The drone is armed in stabilized mode, allowing the operator to have full control over the drone. Missions are executed autonomously in Auto flight mode by using GPS coordinates; however, the operator can have full control by flipping the switch positions on the transmitter and allowing manual control.

Results

These are the elements that pertain to the construction of the quadcopter, and the challenges each represents. The hardware has to be compatible in order to make flight and perform tests. The difficulty was in replacing the broken parts of the quadcopter. The weather was not a good ally during the outdoor test.

As mentioned above, the seed dispenser is one of the most important pieces in this project. There were many challenges, re-routes, and tests. The seed dispenser also had to be re-adjusted and re-built a couple of times using recycled materials that could work properly. Before completion of the actual prototype (Figure 6), few approaches were taken; however, most were inefficient. Although these attempts did not work, the use of recycled material was quite useful. The "screw propellers" made with laundry detergent bottles are fixed in the central axis attached to a dc motor. Then, after the motor is activated, seeds would fall from the seed container (built-in from seasoning bottle) through the hand-crafted hole inside the container into a selected surface. This method did not work because the container was too narrow and unstable, and the seeds were trapped between the "screw propellers."

After some tests and observations, a larger seed-releasing compartment and propellers were made, creating more precise and smooth rotations. The new propellers and the curvature used to create the desired screw effect caused a defect on the central axis that inhibits the passage of seeds through the container (Figure 8). However, this also turned out to be not so much of a good method either.

The dispensing of seeds into a soil surface is delegated by the GPS coordinates once generated, previously generated, or by manual control of the operator.

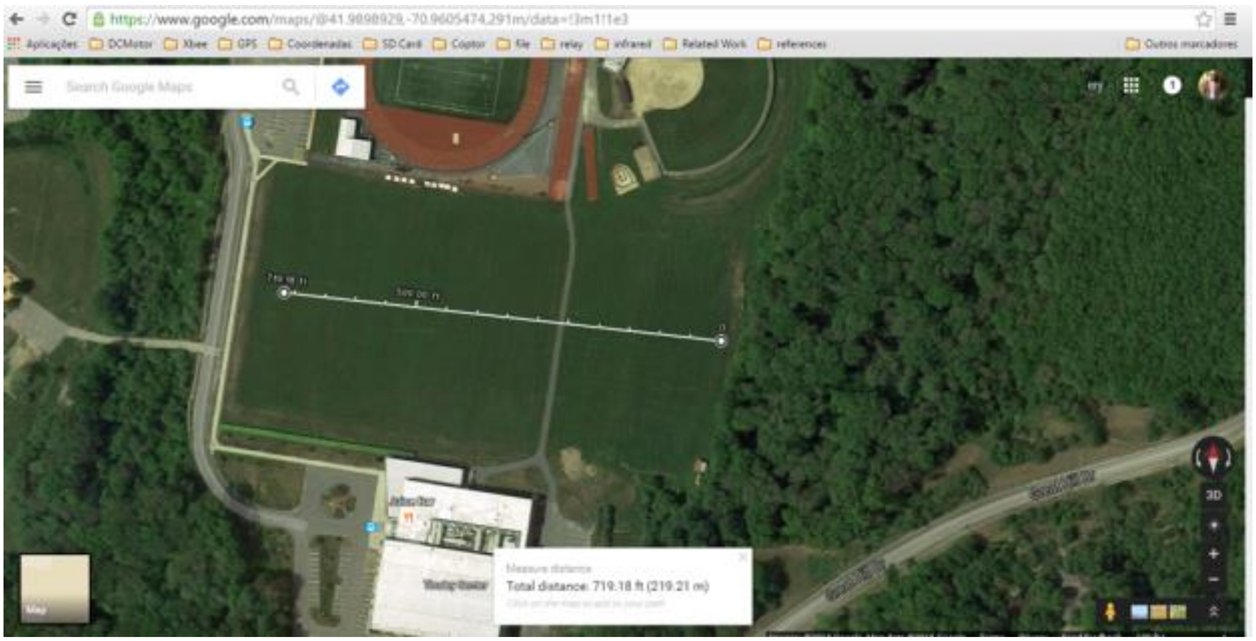
Figure 8- Old Seed Dispenser

The radio receiver will send a PWM signal, a servo motor, that activates or deactivates the motor to start the process of seed dispensing.

During tests, the radio-control system used provided a maximum distance of approximately 719 feet (219 meters) (Figure 9). Tests were made using the above measurements for security, avoiding the possibility of colliding with people or private property. But, in case the radio control loses signal, the "Fail Safe system" will be activated, and the quadcopter will land at the position that the signal was lost.

During tests, there were a couple of falls, and some pieces were damaged, such as the frame arms, motors, and propellers.

Figure 9- Reached Distance



Conclusion

I believe that as computer scientists, it is our duty to develop and produce technological results that can significantly improve the life quality of humanity.

I can personally see this project as an ambitious one that can probably bring universal, innovative trends to the world. I'm optimistic that this project will be a valuable contribution for reforestation and therefore ecosystem restauration. Mindful that the process of seed dissemination will be fast and low cost compared to the overlapped issues we may face along the road. Therefore, I have full confidence that significant gains will be achieved with conventional reforestation. However, changes sooner or later will be unstoppable, only because we cannot afford to lose one of our most supportive lines of survival by keeping only the traditional or conventional methods of reforestation. In specific countries with poor agriculture practices, desertification and deforestation are common problems. For instance, tropical places such as Brazil, Amazonian and Cape Verde Islands are a few from the leading list of places that suffer from these issues. My mentor and I tried to develop a precise, efficient, and affordable solution that can potentially fight or manage desertification, a problem that severely affects my homeland, Cape Verde, and the world. I carry this issue close to my heart due to the fact that I have been personally interconnected with this issue, and I have also dealt with the consequences of harsh climate and insufficient agriculture.

In overview, this project leads to four main accomplishments:

• A custom-built quadcopter that is able to perform autonomous flights using predetermined GPS coordinates;
• Fail-safe system that can provide autonomous landing in case there is any loss of communication between quadcopter and quadcopter;
• GPS coordinates generator software able to plot waypoints of the entire mission trajectory determined by the initial and final waypoints of a selected area;
• A crafted and built robotic seed dispenser controlled by an Arduino and radio control.

Future Work

These three months of work, effort, and dedication developed the best product possible, even though time was limited. Unfortunately, there are still a few problems to repair for the complete functioning of seed dispensing based on GPS coordinates. Therefore, the precision of a seed-releasing operation is still a work in progress. Still, there is always space for improvements in the following areas:

• Make it more environment friendly by installing portable and smaller solar panels or rechargeable pads, capable of providing enough power sources;
• Provide thermal sensors that can detect possible forest fires and scan for clear-cut areas in need of reforestation. Occasionally and autonomously patrolling and sending notifications to the ground station in case of high temperature change and consequently possible forest fires;
• Provide a "field scanner" as necessary and required software, combined with machines able to scan and map the potential areas for forest restauration.

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Appendix

Acronyms Used in Article

APM	Ardu Pilot Mega
CCW	Counter-Clockwise
CW	Clockwise
DSMX	Digital System Multiplexer
ESC	Electronic Speed Control
GPS	Global Positioning System
MavLink	Micro Air Vehicle Link
PPM	Pulse Position Modulation
PWM	Pulse Width Modulation
UAV	Unmanned Aerial Vehicle
ZigBEE	Wireless Protocol

About the Author

Erico Pinheiro Fortes was born in the city of Porto Novo, Santo Antao Island, Cape Verde. Erico completed his high school degree in the technical school of Joao Varela in electricity and electronics in July 2007. He moved to Sao Vicente Island in 2008 to pursuit his higher education in engineering, informatics, and computers at the University of Cape Verde (UNICV). In 2012, he worked at the IT Support/ Help Desk as a trainee both in UNICV Educational Department of Engineering and Marine Sciences and the Department of Social and Human Sciences. In addition to this training, he worked as a computer technician at the Medical Clinic Cirumed from April 2013 through February 2014. In 2013, Erico graduate from UNICV with an undergraduate degree in engineering, informatics, and computers. In 2014, he participated and was selected to receive the national scholarship/partnership between UNICV and Bridgewater State University (BSU), with the opportunity to complete a Master's Degree in Computer Science. He graduated from Bridgewater State University in May 2016 with a Master's Degree in Computer Science. Erico worked from March 2015 through August 2016 at Pedro Pires Institute for Cape Verdean Studies as a research assistant.