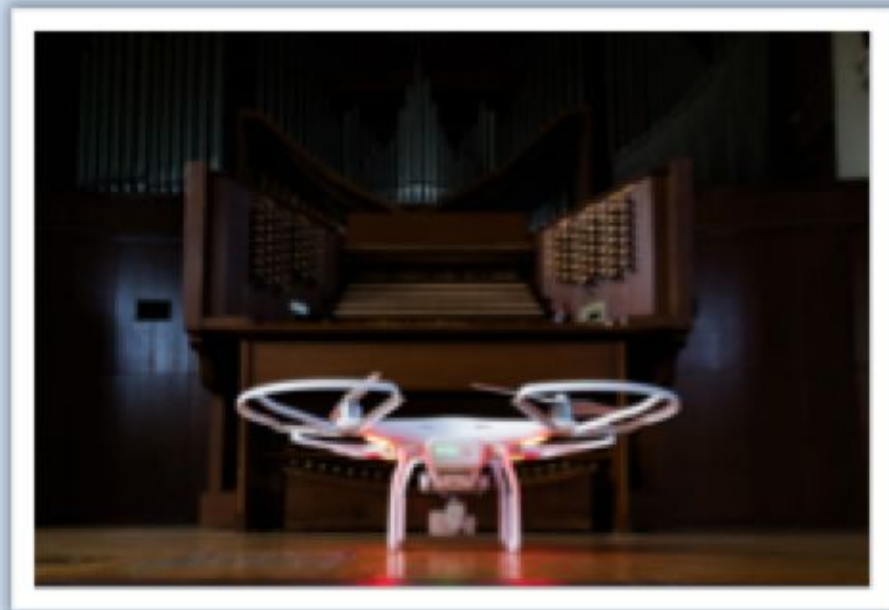


# Brain Drone Race

## Drone Racing Through BCI

Bhaveek Desai, Ernest Williams, Gabriela Buraglia, Luigi Ricard, Kerollin Francois



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# Introduction

## Purpose

This manual aims to be a detailed exposition of the end-to-end process of a Brain-Drone race. Targeted readers include hobbyists, enthusiasts, teachers, student groups, institution heads; essentially anyone who wishes to conduct a Brain-Drone Race. The idea is to encourage more communities to conduct such races in order to stimulate students' interest in the field of Brain Computer Interface (BCI)<sup>1</sup> and Computer Science in general. This document is the result of numerous tests, attempts, trials and errors, and fixes that led to the successful hosting of the world's very first Brain-Drone Race at the University of Florida (UF). It strives to be a simple do-it-yourself guide that could be followed by anyone regardless of their background and understanding of programming. Coming up with a new innovative sport is one thing, disseminating information about it so that more people embrace the idea is what this document is trying to achieve.

## Background

The first Brain-Drone Race took place on April 16, 2016 at Ustler Hall on the UF campus. The team who carried out this feat was a research group under Dr. Juan E. Gilbert. The team was lead by PhD students, Chris Crawford, Marvin Andujar and France Jackson. Assisting them was a group of undergrad students, Nicholas Smith, Eric Agredo, Purnell Jones, Alexander Nunez, Natalia Pulido and Jeremy Zhang. The project was funded primarily by Intel with help from National Science Foundation (NSF), UF, and Human-Experience Research Lab. The race had 16 UF students competing for several prizes and the ultimate title of champion of the first Brain-Drone Race. In the months preceding the race, this team diligently prepared and organized the essentials for this competition. Here we have documented their work to the best of our abilities, and suggested possible improvements for future teams that wish to organize a similar event.

## BCI Overview

In the past, BCIs have often been utilized to help replace, supplement and improve the lives of physically or communicatively impaired individuals. In more recent research, people have explored the use of BCI systems to enhance more common activities that might be more applicable to the general public. BCI is a communication means between the brain and a technological device.

There are two broad categories that are being explored: passive and active BCIs. Passive BCIs measure brain activity to classify a user's mental state, emotion or reaction without the user consciously making an effort. Active BCIs measure brain activity by having users

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<sup>1</sup> Brain Computer Interface (BCI) is further defined in glossary.

focus their thoughts to execute a specific command in an application or machine. Active BCIs can either be independent of external events or be elicited by external events, in which case the system would be referred to as a reactive BCI<sup>2</sup>.

For the first Brain-Drone Race, an active BCI system was developed through the use of electroencephalography (EEG)<sup>3</sup> data. EEG displays the electrical activity of the brain and then amplifies it in order to view and analyze it. This kind of system uses sensors and signal processing components that acquire and analyze brain activity to directly establish a reliable communication channel between the brain and an external device<sup>4</sup>. In the race, the system was trained to recognize participant's "neutral" and "push" states. When a participant's electrical brain activity matched the "neutral" state, nothing happened. However, when the brain's electrical activity matched the "push" state, the drone took off, and subsequently moved forward.

## Regulations

Operating Unmanned Aerial Vehicles (UAVs) in a manner that is congruent with regulations at the Federal, State, and local levels is extremely important. These regulations weren't intended to be restrictive for the sake of rulemaking, but they serve to protect the public trust, and to encourage a safe flying environment. They exist as a way to provide a level of accountability for the people/entities that fly UAVs. Listed below are the steps that need to be executed in order to ensure compliance. Please be sure to read and follow all the steps with explanations listed below in their entirety as not following closely could result in being non-compliant.

1. As of December 2015 the Federal Aviation Administration (FAA) requires all UAVs between ½ a pound to 55 pounds to be registered via their registration portal.
  - a. Follow the link <http://registermyuas.faa.gov> to start the process of registering your UAV. A \$5 registration fee is required.
2. A certificate of registration as well as a unique registration number will be provided instantly after registration via download as well as via e-mail. **It is required that you keep the certificate of registration on hand when flying the UAV. Also, the registration number must be visible on the aircraft.** The registration number can be engraved, or written on the UAV with permanent marker.
3. The FAA memo dated May 4th, 2016 allows UAV flight at educational institutions provided that there is no compensation or commercialization as a result of an event. It is important to note that the students must be the ones who primarily operate the

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<sup>2</sup> Marvin Andujar, Chris S. Crawford, Anton Nijholt, France Jackson & Juan E. Gilbert (2015) Artistic brain-computer interfaces: the expression and stimulation of the user's affective state, *Brain-Computer Interfaces*, 2:2-3, 60-69, DOI: 10.1080/2326263X.2015.1104613

<sup>3</sup> Electroencephalography (EEG) is further defined in glossary

<sup>4</sup> Embedded EEG-Based Brain-Computer Interface," *Lecture Notes in Computer Science*, pp. 1038-1045, 2009.

UAV. Teachers or professors should only provide training and assistance according to FAA regulations. **This document must be printed out and kept on hand during any and all UAV flights.** You can locate the document through the following link:

[http://www.faa.gov/uas/resources/uas\\_regulations\\_policy/media/interpretation-educational-use-of-uas.pdf](http://www.faa.gov/uas/resources/uas_regulations_policy/media/interpretation-educational-use-of-uas.pdf) or by searching on google for Interpretational Educational use of UAS.

4. Before conducting any flights outdoors, local law enforcement must be notified at least one day ahead of time, but preferably a week before flight. If on a college campus, campus police and any other public safety entities must be notified before flying on school grounds. There may be a case where law enforcement and public safety entities aren't familiar with the current rules. In that case, they must be shown the FAA memo permitting UAV flight under the direct control of the students.
5. According to FAA regulation UAVS must not be flown within a 5-mile radius of an airport. UAVs must be operated within line of sight. The maximum altitude allowed for UAV flight is 400 feet above ground level (AGL). In order to ensure the area you choose to conduct the drone race is compliant you can use a web application called AirMap. Airmap is a dynamic visual database of no-fly zones.
  - a. Follow the link <https://app.airmap.io/> . A map will be shown with a "Search by address" input bar.
  - b. Type in the location where you plan to use the UAV into the search bar
  - c. Click the "Select All" link located in the window pane located on the right of the screen. This selects all available no-fly zone options..
  - d. On the same window pane located to the right of the map, deselect "Commercial-Blanket COA, as well as "Schools" which is located toward the bottom of the pane.
  - e. What now displays on the map are circles which are the no-fly zones. You are able to conduct the drone race in any areas not covered by the no-fly zone circles.

Reminder of must have documents while flying:

- ✓ Certificate of Registration
- ✓ FAA memo

## Equipment and Tools

This section dives into the necessary tools you need to get you up and running with the technical setup for the Brain-Drone Race. It also explains the installation and configuration process where necessary.

# Hardware

To start off, following is the list of hardware and their respective specifications (please note that one set of hardware is required per participant in a given race):

## Drone Choice

There are two options for drones that can be used. The choice of drone should be made based on personal preference. The pros and cons for each drone will be listed.

### 1. DJI Phantom 3 Professional Drone

This was used during the first Brain-Drone race. It is a very powerful and sophisticated drone. However, it is more difficult to use than the Bebop 2 and somewhat of an overkill for the purpose of a Brain-Drone race. This drone has an extensive set-up process in order to fly it using a BCI device, which can be seen in the DJI specific setup sections..



### 2. Parrot Bebop 2 Drone

This drone was tested following the first drone race. It is much smaller and easier to use. Because of its size, it does a better job of hovering and flying straight in doors. The setup process for using the Bebop 2 with a BCI device is very simple. This drone is also significantly less expensive than the Phantom 3.



Optional but highly advisable accessories:

a) Propeller Guards: This ensures the propellers don't collide and undergo damage. Also, the presence of propeller guards reduces the risk of cuts and personal injury when handling the drone while in flight. These are commercially available for the DJI drones. However, for the Bebop2, because these are not sold by Parrot, they will need to be 3D printed using the STL files provided in the 'Bebop2' folder in Google Drive titled 'Prop\_guards.zip'. You must 3D print each file twice. Once you have the 3D printed propeller guards ready, please follow the following video to learn how to install them.



b) Heavy Duty Gloves: Protects your hands when handling/re-aligning drones while in flight.

## 2. EMOTIV Insight

This is the brain of the Brain-Drone Race. Insight is a lightweight 7 channel EEG device from EMOTIV . This headset allows signals from the user's brain to be captured and sent to the computer for further processing. You may also use the EPOC+ EEG headset from the same company. While EPOC+ is an older model and provides higher fidelity with 14 channels, Insight is easier to use and requires little maintenance.



There are other EEG devices available from other vendors, but we recommend these because of their existing suite of applications that allow mapping thoughts to triggers. This is further explained in the 'Software' section that follows.

## 3. Android Tablet - Required only if using DJI Drone

An android tablet will act as a controller which fetches commands over Internet and translates them to respective actions for the drone. The ASUS Nexus 7 was used for the first

Brain-Drone Race. The android tablet is required to have following minimum specifications:

- Android 6.0 Marshmallow
- 2 GB RAM
- 1 GB free space
- Non-Intel® based processor (There isn't sufficient testing conducted with Intel® based tablets)
- WiFi/Cellular data connectivity

#### **4. Laptop - Required for either drone**

We recommend a laptop with following minimum specifications:

- Microsoft® Windows XP / Mac OS X
- 2 GB RAM
- 5 GB free space
- Dual core processor @2.15 GHz
- 1 free USB port
- Internet connectivity

## **Software (for both DJI and Bebop2)**

In order to get started, you are required to install certain softwares on the laptops that you'll use for the Brain-Drone Race. You must create a free account with Emotiv in order to get the software. Create your free account here:

<https://id.emotivcloud.com/eoidc/account/registration/>

Following is the list of software along with the details on how to get them. All the software required are available free of cost.

Once you've created your EmotivID, login to be able to download the following software:

1. Emotiv/Xavier Control Panel:
  - a. Visit: <https://emotiv.com/my-account/>
  - b. Under 'Available Downloads', click on 'EMOTIV Control Panel – Xavier Control Panel - Windows'
2. Emotiv EmoKey:  
Bundled with the control panel

We recommend you use the same browser we did, for consistency purposes

1. Google Chrome Web Browser:



Download from here:

<https://www.google.com/chrome/browser/desktop/index.html>

The files and codes specific to drones are available here: <https://goo.gl/XZM3f6>. We shall refer to this as 'Google Drive'.

## Bebop 2 Specific Software

Before the code for controlling the Bebop 2 can be run on your laptop, you will need to install the Node.js Javascript platform on your computer. To do this, follow the steps below.

1. On the laptop you want to use, connect to the internet, and navigate to the website [nodejs.org](http://nodejs.org).
2. Select the downloads tab.
3. On this screen you will see 'Windows Installer', and 'Macintosh Installer'. Choose the one that works for your specific device.
4. Once the file is downloaded, double-click it to run the Setup Wizard.
  - a. No special settings must be changed, so click through the wizard and accept agreements as necessary. When done, click finish.
    - i. If you are using a Windows machine, you will now have an application called Node.js installed on your computer.
    - ii. If you are using a Mac, you will not see an application installed on your computer.

Now that you have installed Node.js, you will need to install a few Node.js clients to allow our program to work. To do this, follow the steps below.

1. Open a Command Prompt(Windows) or Terminal(Mac) window on your device.
  - a. To do this on Windows, open the Start menu by pressing the windows key, and type 'cmd' in the search menu. Click the application to open it.
  - b. To do this on a Mac, click the search icon in the top right corner of the screen and type 'Terminal' . Double-click the application to open it.
2. Once in the Command Prompt or Terminal window, type the following(press enter after each line)
  - a. npm install keypress
  - b. npm install node-bebop

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^b\aN[X[ ZN]X #
.
```

With these steps completed, you are now able to run the code that allows you to fly the Bebop 2. This code can be found at the following link. **Will put on brain droning**

**gmail** Download the 'bebopDroneRace.js' from the folder 'Bebop2' in Google Drive and place it somewhere you will remember in your computer's directory. I recommend placing it on the Desktop. Take a look at the file to get an understanding of how it works. Pressing the 'w' key causes the drone to take off if it's on the ground. If pressed again, after take off, 'w' will make the drone move forward. This is done to make the drone fly using the Emokey software. Pressing the spacebar will cause the drone to land.

## Process

### Pre-Race

#### Promotion

Promotion is an integral part in the development stage of any event. Once a target audience has been identified, the media most relevant and accessible to this audience should be explored. For the first Brain-Drone Race, several University of Florida listservs were utilized, flyers were posted at libraries and a Facebook event was created.<sup>5</sup> Facebook is a very useful platform to reach people from various age groups. E-mail listservs also go a long way, especially when they target smaller groups of people. At the college level, departmental newsletters and student organizations are also an instrumental tool to share information. By notifying organizations, they can share the information with their members. Organizations that have explicit interests in computer science, technological innovation, medical advancements, engineering, and/or drones would be especially useful. Besides virtual tools, having a representative physically go and promote the event at student organization general body meetings or at large lecture halls can have a positive effect. At the grade school level, parents could be notified through sources such as parent-teacher association meetings.

#### Participant Pre-Selection

Once enough participants have been recruited, there must be a system to filter who proceeds to the qualifiers. For the first Brain-Drone Race, over 400 students filled out the survey that was sent out via listserv. Of those 400 interested, 100 were accepted. In an attempt to achieve a diverse participant pool, the survey asked interested parties to identify a country of affiliation. Two people from each country were then chosen, with the exception of the U.S. However, people arbitrarily selected countries they wished to represent instead of picking their heritage countries. Although this attempt at

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<sup>5</sup> Facebook Event link: <https://www.facebook.com/braindronepace/?fref=ts>

For more UF-specific information please view UF-only Appendix

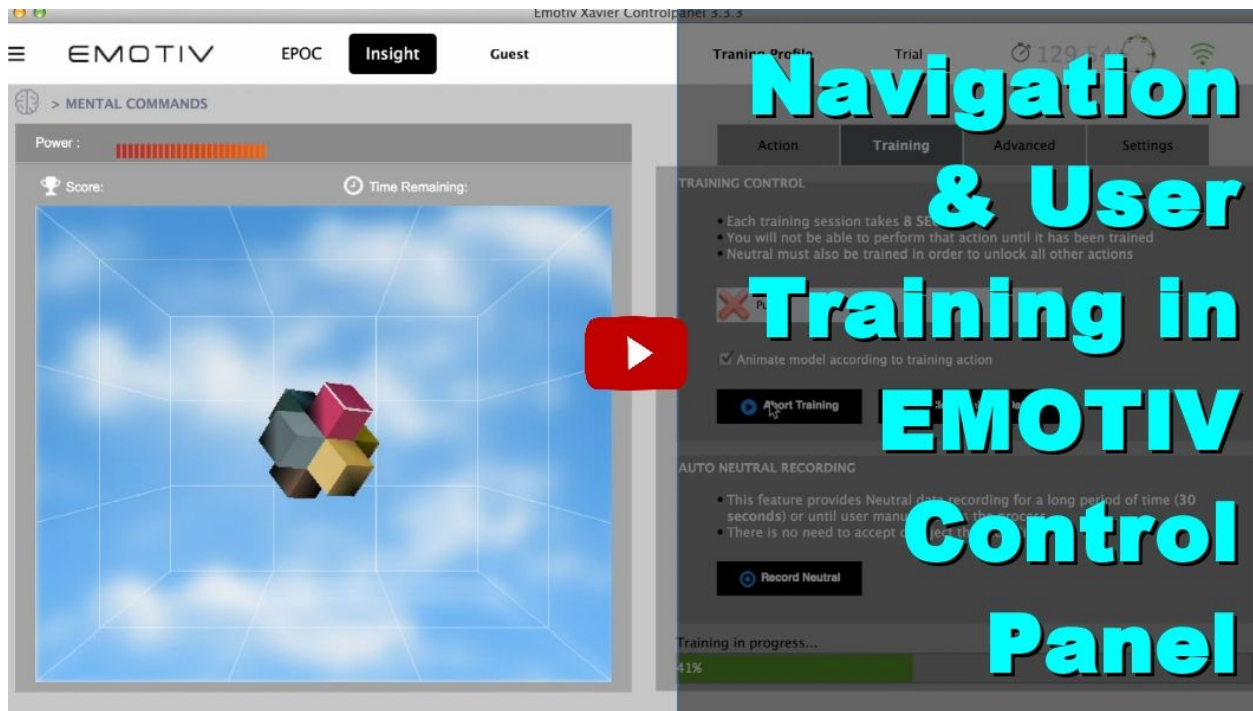
diversification wasn't fruitful, it is an important consideration to have when organizing such an event. A possible way to pursue diversity is to request interested students to identify their respective majors at the college level and select a set number to represent each major. At the K-12 level, a possible categorization approach could be by age group. These are just two simple alternatives, but there are plenty of other options that can be explored.

## Qualifiers

After a list of willing participants is compiled, qualifiers must be held in order to trim the number of contestants down to a number that is manageable for a final tournament. For the first Brain-Drone Race, 16 participants were selected for the first round, but other formats can be used at the discretion of the organizer.

The qualifiers are held using a simulation that reacts to the signal used by the BCI to control the drone. Using the BCI headset, first record training data for each participant. To do this, record their neutral state (when they are calm and relaxed), as well as their active state (when they are thinking about pushing or moving forward). For more information, please view the videos below.





Once that information is recorded by the system, the participants partake in a simulation on a computer to test their ability with BCI. The original simulation consisted of a virtual drone that flew down a basketball court, with a timer that stopped once a certain distance was reached. Four runs were conducted, with the slowest run dropped and the other 3 times averaged out. Using the averages obtained from all the participants, a ranking was established, and the top 16 qualified for the tournament.

To conduct simulation:

1. Download & run simulation from Google Drive
2. Follow steps 5 through 10 under 'Laptop' listed in the following sub-section 'Technical Setup (for DJI drone)'
3. Bring the simulation window to the front
4. Press spacebar to land the virtual drone

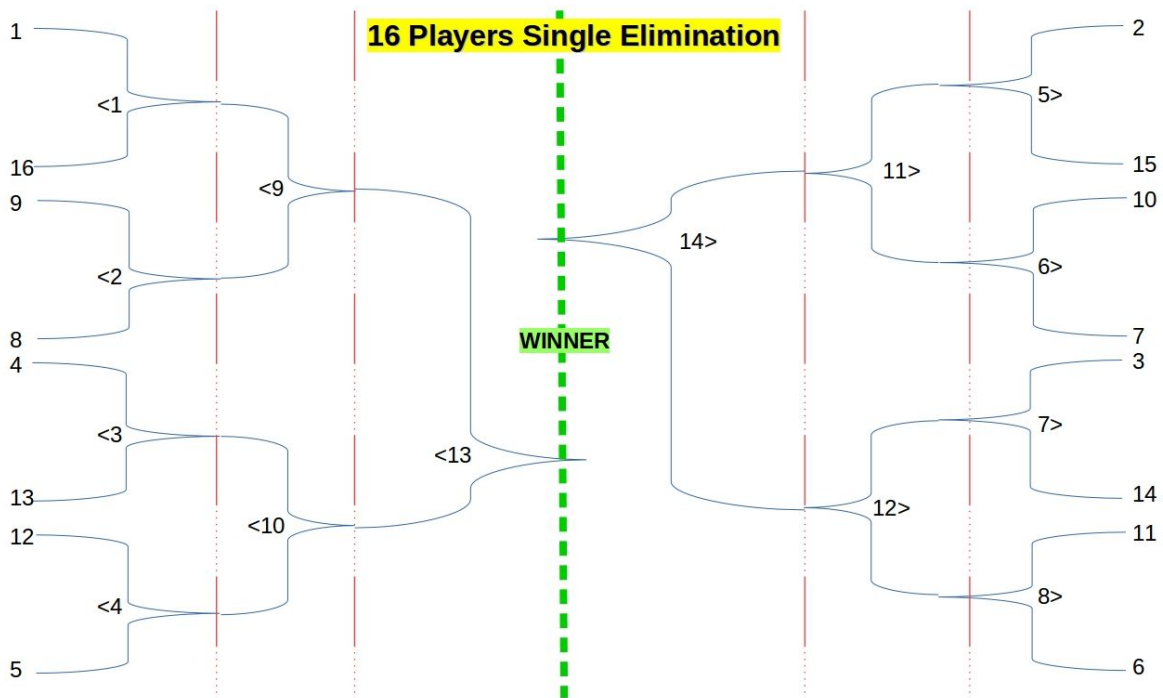
Each participant must participate in the qualifiers individually and with as little disturbance as possible. This means that, depending on the number of participants and the amount of available EEG headsets for qualifiers, this part of the tournament may take a fair amount of time. Therefore, adequate planification and time allotment should be taken into consideration. For the first Brain Drone Race, qualifiers took place in a room different from the competition site. We recommend that for consistency purposes, qualifiers be conducted at the competition site if possible.

# Race

## Race Rules

Race rules can be modified as the organizer sees fit in order to meet the specific needs of each event. However, we would like to present the rules from the first Brain-Drone Race and highlight the strengths and weaknesses of this approach. The first Brain-Drone Race was conducted drag race style; two drones raced in a straight line for a certain distance. The first drone to cross the finish line was the winner.

Each race was conducted on a best 2 out of 3 approach. This method was chosen in order to conduct a fair and unbiased race. However, this considerably extended the overall time of the race. In order to reduce time spent, we suggest having single elimination for all races from the beginning.



The race was conducted in a bracket format. Positions 1-16 were determined by the top times from the qualifiers, position 1 being the fastest time.

Each race was conducted as the diagram depicts, where participants with faster times in the qualifiers were paired with those who had slower times. In round 3, the winners of

aces 13 and 14 competed for the 1st and 2nd place while the losers competed for the 3rd and 4th place.

## Race Setup

*Before flying either drone, we recommend that you calibrate them. Videos on how to calibrate each drone have been included in the FAQ section.*

### Technical Setup (for Bebop2 drone)

To fly the drone, follow the following steps.

1. Turn on your Bebop 2 by pressing the button on the rear of the drone once.
  - a. The drone takes a few seconds to start up completely. When the rear LED turns solid, the drone is ready to fly.
2. Once the drone is ready, navigate to your laptop's Wi-Fi menu and search for a network with 'Bebop 2' in the name. Select that network and connect to it. **When using two Bebops simultaneously, make note of which network corresponds to which drone to prevent confusion.**
3. Once your laptop has connected to the drone's Wi-Fi, open a Command Prompt or Terminal window. Use the change directory command to navigate to the location where you store the bebopDroneRace.js file. If you place it on the desktop, type 'cd Desktop' and press enter.
4. Once you have navigated to the location of the file, type the following command: 'node bebopDroneRace.js' and press enter. You should see 'Ready to Fly' in the command prompt.
5. Once 'Ready to Fly' is displayed, you can use the 'w' and spacebar key to test your connection.
6. After landing the drone, press the 'Control' key and 'c' together to stop the program from running.

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^b\aN[X[ ZNX#**

### Technical Setup (for DJI drone)

This section addresses the race setup from the technical standpoint and covers everything there is in terms of getting different pieces of tools together. Following is the list of steps that needs to be followed in order to successfully setup the race:

1. Laptop
  - %" Turn ON the Laptop
  - &" Connect to Internet

- ' " Open Google Chrome
- (" Open the web application:  
<http://ec2-54-188-142-106.us-west-2.compute.amazonaws.com:8081/mamanode/#>
- ( "% Select 'Drone 1' under 'Participants' for participant 1 & 'Drone 2' for participant 2
- ("&" Open another Instance of the web application in a separate tab/window
- (" " Select 'Count Off'
- )" Open Emotiv EmoKey
- ) "% Click 'File'>'Load mappings'> select 'drone\_race.ekm' from the folder you saved it in
- ) "&" Click 'open'
- \* " Plug-in the USB dongle to the Laptop
- + " Open Emotiv/Xavier Control Panel
- + "% Click on the hamburger menu on the left and select 'Detection '>'Mental Commands'
- + "&" Click on 'Profile'>'Select Profile'> your profile
- , " Wear the Emotiv Headset and turn it ON
- " Check the sensor status in the icon on the Control Panel and adjust the sensors on the head if necessary
- %\$" Ensure the 'push' command is working

## 2. Drone

- %" Place the drone on the ground on the 'START' location
- &" Orient the drone in such a way that the battery is facing opposite of the direction you want it to fly
- ' " Press the power button twice and hold until all the bars on the battery light up
- (" You should hear a short, distinct sound indicating the drone is now powered ON





### 3. Tablet & Controller

- % Connect the tablet to Internet
- & Mount the tablet on the controller and connect the two using the USB cord
- ' " On the controller, press the power button twice and hold until all the dots light up
- (" Open the Drone-Race app on the tablet
  - ("%" Navigate to 'Flight Operations'>'Virtual Stick'
  - ("&" Select 'Drone 1' for participant 1 and 'Drone 2' for participant 2



# Navigating the Brain- Drone Race Android App



#### 4. Let's Go!

- % Open the web application 'Count Off' page and first click on 'Reset race' and then on 'Start race'
- & Open the web application 'Drone 1/2' page and make sure this window is active and other opened windows are pushed to the background
- ' On the count of 3, each participant starts thinking of 'pushing'
- (" To stop the drones, hit the space key on the 'Drone 1/2' page

#### **Nontechnical setup**

For the first Brain-Drone Race two tables were set up, one for each participant. On each table was a laptop with a connected EMOTIV headset. The DJI drone controllers, each with a tablet, were placed directly behind the starting position of each drone. A red line was placed from the starting point to the finish line and at the finish line a large piece of green paper was placed.

These color indicators were intended to serve as guidance for the drone through the line follow program in the code. However, there were still a considerable amount of issues with keeping the drone straight. Additionally, LED lights were used to outline the racetrack and a movable fence was placed around the track as well.

Other set-up details were that replacement drone batteries were kept charging throughout the event. Each battery takes approximately 2 hours to charge. Whenever the batteries reached 2 bars they were replaced in order to ensure optimal drone performance. Also, on one side of the racetrack an announcement podium was placed and there was enough space left for team members to maneuver around the track. And lastly, there were "drone

handlers” on the track at all times who helped recenter the drones when they veered away from the red line. These handlers wore heavy duty gloves at all times and exercised great caution.

## **Recording Scores**

The time of the winning contestant is recorded automatically upon the referees ending the race. This happens when a drone is adjudged to have crossed the finish line and the referees issue the Global Land command. The time is added as a new entry into an Excel spreadsheet so as to be easily comparable to prior and subsequent times.

## **Post-Race**

### **Publishing scores**

Like in any race or competition, publishing scores is an essential detail for participants and the audience alike. The scores for the first Brain-Drone Race were published at [braindrone.com](http://braindrone.com). However, there were several drawbacks to this publication. Participants’ actual times were not posted; all that was stated was who won each race. Furthermore, the published scores were inaccessible from a mobile device.

When publishing scores, it’s important to report actual race times and each race winner. For maximum accessibility, scores should be accessible via mobile and stationary devices in real time, not just post race.

We also suggest that race times be posted visually during the race through the use of a scoreboard or by similar means, as well as announced verbally. Although this wasn’t done for the first Brain-Drone Race, it is customary of many other races and will add a considerable value of excitement to the competition.

## **UF-only Section**

### **Promotion**

For most e-mail listservs at UF you can request the usual senders to divulge information on your behalf. Such a listserv is the Engineering Undergraduate listserv, currently sent out by LaToya King .<sup>6</sup> Another place to post event information is directly on the UF engineering

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<sup>6</sup> LaToya King’s email: [Lking@eng.ufl.edu](mailto:Lking@eng.ufl.edu)

calendar.<sup>7</sup> You can request promotion on the engineering website and other social media belonging to student groups like Gator Engineering and the main UF account; for help with promotion of this sort, contact Jen Sijun Li.<sup>8</sup> If you are interested in promoting the event to companies outside of UF you can contact the director of corporate relations, Kim Jacobs.<sup>9</sup>

## Room Reservations

For testing purposes we struggled to find testing sites. Although there are many other options, including some we might have overlooked, the only one we found success with was the University Auditorium.<sup>10</sup>

## Glossary

**Active State:** The state of a participant when they are thinking about the command they are trying to send to the drone.

**Brain-Computer Interface (BCI):** A communication means between the brain and a technological device. BCIs read electrical signals or other manifestations of brain activity and translate them into a digital form that is technologically understandable in order for the brain activity to become useable data.<sup>11</sup>

**Electroencephalography (EEG):** Measures electrical brain activity through sensors called electrodes that our placed on the scalp.

**Global Land Command:** The command sent by the referees to land all active drones and end the race.

**Neutral State:** The state of a participant when they are not thinking of anything in particular.

## FAQ Section

### For DJI hardware

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<sup>7</sup> Event submission link: <https://www.eng.ufl.edu/news-events/events-calendar/submit-an-event/>

<sup>8</sup> Jen Sijun Li's email: [jenli@eng.ufl.edu](mailto:jenli@eng.ufl.edu)

<sup>9</sup> Kim Jacob's email: [kmjacobs@eng.ufl.edu](mailto:kmjacobs@eng.ufl.edu)

<sup>10</sup> University Auditorium contact: [jdegen@performingarts.ufl.edu](mailto:jdegen@performingarts.ufl.edu)

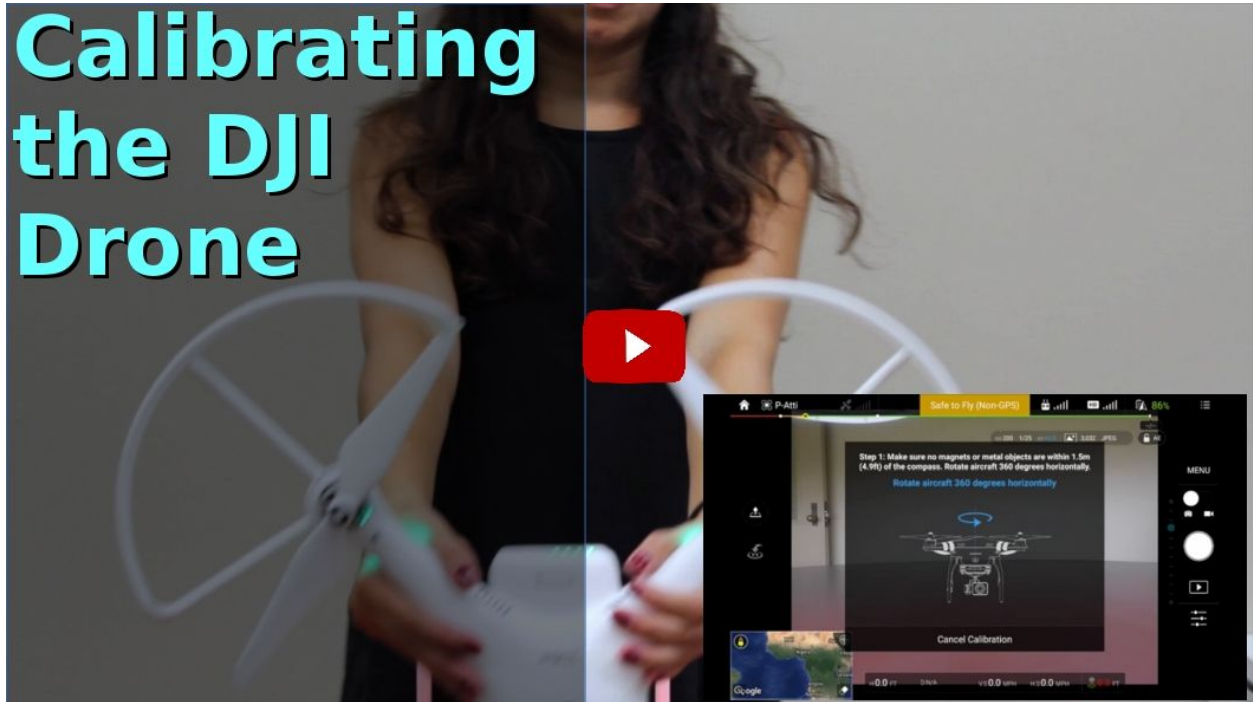
<sup>11</sup> Ortiz, S. "Brain-computer interfaces: Where human and machine meet." *Computer* 40.1 (2007): 17-21.

Q) My DJI Drone won't take off, what do I do?

A) Check that front LED lights are green, otherwise indicates it is not safe to fly.

Q) My DJI Drone is flying poorly, how can I fix this?

A) Make sure to calibrate drone before flights, especially when in a new area. Please watch the following video to learn how to calibrate the DJI drone:



Q) What do I do if the DJI app doesn't display the camera visual?

A) Go back to app menu select Camera>Record video, then go back to original screen.

Please refer to following video for more information:



Q) Will this work if I have an EEG headset from other vendors (Neurosky, Muse, etc)?

A) The setup detailed in this document would only work with Emotiv EPOC+/Insight

Q) I don't see sensors light up when I open the Emotiv/Xavier Control Panel. What do I do?

A) Ensure the headset is sufficiently charged and is turned ON and the USB dongle is connected properly (You should see a small light on the dongle if it's connected properly). If the problem persists, close the control panel, reconnect the USB dongle and restart the control panel.

Q) Why is the 'Skill Rating' for my profile so low?

A) Your skill rating will increase with the amount of times you go through the training process.

Q) There is some noticeable delay when a command is issued and the drone responds. What is the problem?

A) Ensure you're not on a network that is shared by many people at the same time (e.g. a public or school network). It is better if you use a mobile hotspot as it is less susceptible to bandwidth load.

Q) What do I do if the DJI android app crashes while the drone is in flight?

A) Do not panic, you can regain control by re-opening the app and navigating to 'Virtual Stick'. Ensure you select the same drone (drone1/drone2) that was selected earlier.

Q) What do I do if the DJI drone no longer responds to the app?

A) Do not panic, it could be a network issue. Fortunately, you can still control the drone from the handheld controller. Slowly bring the left controller all the way down to land the drone safely.

Q) The DJI drone drifts considerably off the red line. What do I do?

A) Ensure that the line is wide enough for the drone to identify (a width of 5 inches is typically sufficient). Also, ensure the camera on the drone is pointed all the way down. You can do so with the help of the wheel on the top left corner on the edge of the handheld controller before taking off.

## **For Bebop 2 hardware**

Q) How do I calibrate the Bebop 2?

A) Download the app FreeFlight3 on any mobile device, Connect to the Bebop 2, go to settings once connected swipe over until calibration is seen. Click on it and follow the on-screen directions.

Q) How do I update the Bebop 2?

A) To update the Bebop 2 Firmware you must first download the update. Open your FreeFlight3 app, go to the menu (on Android the 3 bars on the top left corner) then find and click on Check for updates. Choose the bebop 2 then wait for the download to finish. Once completed connect to the Bebop 2 wifi and go to the 'Check for updates' option once again and follow the on-screen instructions.