Ashank Behara

HS intern

Pennovation Center (Grasp Lab)

Start: 10 July 2017

User Guide for Vicon at UPenn's Pennovation Center

Optimization of energy and movement based upon "sweep, offset, and duty cycle"

The duty cycle is percentage of the time spent in the slow stage

The offset is how far off (in degrees) the leg is from the center after completing a cycle

The sweep is how far (in degrees) the leg moves when making a cycle.

One use of Vicon in the lab it to test optimization and compare it to an algorithm created by Mr. Reverdy (Post-Doctor) and another graduate student. The markers used are placed on drones and robots.

A note on sources: There are many sources of documentation for the Vicon system available online. This guide summarizes information from the following sources:

1) **https://www.evl.uic.edu/sjames/mocap/tutorial.html#startup:** A very useful page giving a brief introduction of each individual part of setting up the Vicon system.
2) **https://docs.vicon.com/display/Tracker34/Tracker+documentation:** The guide went very in depth into all of Vicon Tracker Software and is the official documentation.
3) **https://www.youtube.com/user/Vicon100:** The youtube page provided a very in depth guide on how to calibrate the system using the magic wand and also apply masks to the cameras.
4) **Paul Reverdy and Maria Matthews:** I talked to both of them and they both gave me very helpful information regarding the Vicon Tracker System. Mr. Reverdy was especially informative for the introduction and Maria walked me through setting up most of the system and taught me a great deal about data exports.

5) **Vijay Kumar Robotics Lab's Github Page:** Provided a lot of information regarding data streaming and Mocap in general. Detailed tutorials can be found on this page.
6) **http://andrewd.ces.clemson.edu/courses/cpsc412/manuals/Vicon%20Tracker%202%20Manual.pdf:** Vicon tracker user guide published online by Clemson Uni

1) What is motion capture? How does it work?

Motion capture (mocap) is the course of action of recording movements of animate and inanimate objects. The technology was created for the life science market to observe human and animal motion, but is now used widely by neuroscientists, visual effect studios, sports therapists, major technology corporations, and robotics laboratories (UPenn's Grasp Lab). Vicon, the mocap software and hardware used in Grasp Lab utilizes and specializes in Optical-Passive motion capture. This type of motion capture uses retroreflective markers that are placed on objects where they are tracked by infrared cameras. This technique is very adaptable as it works in multiple environments. This also happens to be the most common and effective mocap system.

2) How to start the system (physical power switches, software, etc.)

If cameras are all off, (the blue dots are not illuminated) turn on the switch that is on the extension cord to the left of the computers and the cameras should power on. I was told cameras 12 & 13 behave poorly and 13 stays shut off because it overheats very quickly due to the air conditioner right next to it. Camera 16 is turned off for reasons undisclosed. As long as a few cameras are on and able to track the retroreflective markers, the system should work. Power on the computers and open the "Vicon Tracker Software" which is the green one with a white capital letter T on it. If all of these steps are completed you are ready to start capturing data.

3) Placing markers on a vehicle

When placing retroreflective markers on the vehicle of subject make sure that the markers will not move and are stable. This does not mean that they cannot be placed on a joint

that moves. For example, if a marker needs to be placed to track a wheel, it should not be placed on the treads of the wheel, but rather the center of the wheel where it will not move relative to the rest of the object. The markers can be placed on the object using double sided tape. Industrial grade double sided tape is recommended as security to decrease the odds of the markers falling off however regular double sided tape would work. Glue can be used as well, but it is much easier to replace and move the markers if secured with tape in case of misplacement. It is also important that the markers should be completely visible because if the marker gets covered by part of the mechanism and the camera cannot pick up the data point, you will lose significant precision in the data that one would receive from Vicon. When placing markers make sure to spread out the markers as much as possible because if they are too close together the image you will receive will appear jittery and will make small unnatural movements. Another common mistake is placing markers in similar patterns in multiple locations. The problem with having repeated patterns is that the system would have a difficult time identifying which markers belong to what part of the object leading to significant problems in data analysis.

4) Building models, capturing data, and exporting/saving data

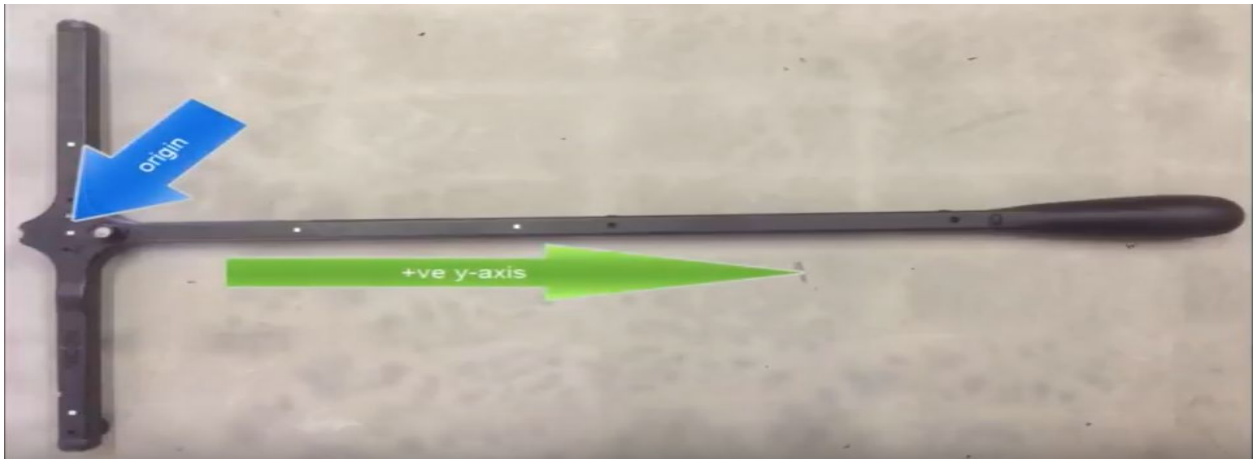
The first tab titled "System"

On the object tab one can see a list of all the cameras linked to the computer and whether they are turned on and functional or not.

The second tab titled "Calibration"

In the case that you need to calibrate follow these instructions: Stay in the System tab at select all of the cameras. Once they are all highlighted, on the top of the left panel in the drop down box change it from "3d Perspective" to "CAMERA". Now switch over to the calibration tab. The first step is to create a mask so click "START" under camera mask and it will mask the cameras from permanent reflective materials. Do not put too many masks because it could prevent the camera from picking up data points.

The next step is to use the calibration wand. The wand has 5 markers and the orientation of the wand determines the orientation of the field



Images and information from (Vicon's Youtube: Calibration)

The positive y and x axis are shown above and the positive z-axis is the product of both of these axes. Use the bubble next to the on and off switch as a level and make sure it is laying flat. Note that this will be the global origin of field. If the wand is not flat you can manipulate the screws on the +x and +y axes to change the level. To turn on the wand flick the switch next to the origin and as soon as you do, the battery lights should turn on indicating how much charge the wand has. If the wand can detect the frequency from the strobe of the camera, the wands LED's should match it. If they do not because the lights are too dim, there is an intensity screw located next to the on/off switch. If you want the wand to send NIR wavelengths turn on the switch on the +x axis, but if you want IR wavelengths turn the switch off. There is another switch next to the origin that controls strobe or continuous. This should be left on continuous

unless there are T160's in the system. As for actual calibration, Always do a Full Calibration with All Cameras. If the option is there, the refinement frames should be set to 1500 and the Auto-stop checkbox should be checked. Press "START" and you will be ready to calibrate. Make sure when you wave that the wand is facing upwards (LED's up). Do not make small movements in front of each camera. Make sure to make large motions that cover a large area as you should try to calibrate the volume as well as the sensors. The cameras will be calibrated when the little triangle at the bottom right changes from a flush red to a dark green. After you have calibrated place the wand back where is was lying before. You can click stop if there is no auto-stop option. Place the wand back where it was previously on the floor. Switch back into the 3d perspective. You will see the wand floating and all the cameras in perspective with each other but off center. This is because the global origin is not set. Press "SET ORIGIN" and the wand and cameras should be in place. The wand can be turned off now. If the calibration is not completely correct one can reset the calibration.

The third tab titled "Objects"

This houses object creation or allows you to choose previously saved objects. In order to create a new object place your robot or drone (with the retroreflective markers already attached) in the field of vision of the cameras. On your computer screen you should see floating white dots in the grid system. "Ctrl+Click" all of the white dots. Make your way to the bottom of the screen to make sure the checkbox that says "Auto-Enable" is checked. Proceed to enter a name of your object and then click the green boxy that says "CREATE". The image that should appear on the screen is not floating white dots, but a rigid body formed by orange lines connected together.

To select an existing object place your robot in the existing REAL LIFE field and scroll through the list of pre-existing objects and select it.

It is important to note that it is possible to add markers. In order to do this click "Add marker" and place a new retroreflective marker on your robot. This will be added to your object on your screen. Because there is a new marker you will need to recalibrate the system and there should be a button to the right of the "Add Marker" button. Press that and calibrate the system again (See the previous step).

You can manipulate the origin of the object by first pausing the live stream. Click on the marker that you want to be the origin. Drag along the x, y, and z axis bars of the transparent cube on your screen to "snap" the origin onto a desired position or marker. You can also rotate your origin and change the perspectives by pressing "r" on your keyboard.

You should REGARDLESS of the situation always right click or "Ctrl+click" on your object and save it.

The fourth tab titled "Recording"

The first step to recording and actually capturing data is to press the button that says "Go live" on the top right of the left panel. The location should be SHARED and you can name the trial accordingly. The first 3 digits of the trial name at GRASP usually refer to what is being tested or played around with. Check the box that says "Auto-increment" and click start to record and test. When you are finished click "stop" and then click "load trial". If there is an error click "reprocess trial".

In order to export and save your data, look under "Export csv" and to change the location of the export, click the ellipsis to the right of the box with the file name. Select a location in a folder on the computer. Once you select the location of the export you can change the device that you are exporting to but it should usually be "NONE". "ALL" objects should be selected to be imported. Click "Export" and all your data will be saved.

5) Data fields that can be exported by Vicon

.csv files can be directly exported by Vicon Tracker software. Microsoft Excel can actually import .csv files and edit them without changing the file type.

Fields that can be exported include

Time (seconds)
Model Position, x (mm)
Model Position, y (mm)
Model Position, z (mm)
Model Rotation, x (rad)

Model Rotation, y (rad)

Model Rotation, z (rad)

ROS is able to obtain linear and angular velocities and Cam may have written software that allows linear and angular velocities to be obtained from the data fields shown above. The formula for linear velocity is $\frac{distance}{time}$ in mm/s and the formula for angular velocity is $\frac{(arc\ length/radius\ of\ circle)}{time}$ in rad/s so it will be very easy to compute these measurements given the data fields that are for sure able to be exported directly by Vicon.

6) Collecting data with ROS

The first step to collecting data with ROS is to go on Vicon and go Live. You can then start a trial and navigate towards ROS. Connect the ethernet cable to your computer and disconnect wireless. Navigate to the catkin workspace.

In src/mocap_vicon/launch:

- Server address value is 'mocap'
- Everything else default
- Can map long model names to shorter name

Start Node:

- roslaunch mocap_vicon vicon.launch

To record:

- Rosbag record <model name> (or shorter name)

If Ros can't find something that's there:

- source devel/setup.bash

If you need to pause/stop recording:

- Ctrl+C

If you need to convert Rosbag file into .csv file:

- Follow the instructions on the following link
    - Rosbag to CSV conversion instructions

7) Solutions to common issues

Common questions regarding software, hardware, operating systems, etc. can be answered directly by Vicon through their FAQs (Vicon FAQs) and more specific problems regarding Vicon that may not be answered on their FAQs can be resolved through their Remote Support page (Vicon Remote Support).

- Camera 12: pops up error because of overheating (backside radiates heat)
    - Restart the system (turn off and turn on)
    - If in between trials press okay when the pop up comes up and then click start before the window pops up again
        - Not really a solution but it is the only solution that was offered
- Cameras come up with red lights
    - The cameras are uncalibrated so you can either restart the system or calibrate using the wand again. The system restart is recommended as it takes less time and effort than re-calibrating.
- Turned on the system and the robot was on the field, but the camera wasn't detecting the retroreflective markers
    - Restart the system

8) Vicon Live Data Streaming

Downloads for the Vicon DataStream SDK is available at this link (Download Vicon SDK). The Vicon DataStream SDK is compatible with Vicon Trackers as well as Nexus, Blade, and other 3rd party software. The DataStream SDK supplies a way for Matlab users to directly and effectively stream data as is it being recorded by Vicon Tracker. Streaming data is only possible through Matlab and ROS. It is better to stream data live rather as you get a live feed of what is happening throughout your trials. It is possible to use Vicon without the stream but if you so choose to, streaming is a very good option.

Instructions to Data Streaming from ROS have been published to Kumar Robotics's GitHub page (Kumar Robotics GitHub Motion Capture) and the instructions are as simple as compiling your code and then launching the correct file, located on the GitHub page, from ROS.