Shannon Stoehr

Creating Kinect Tuning Features

Software Engineering Internship 2023

PLUS ONE ROBOTICS

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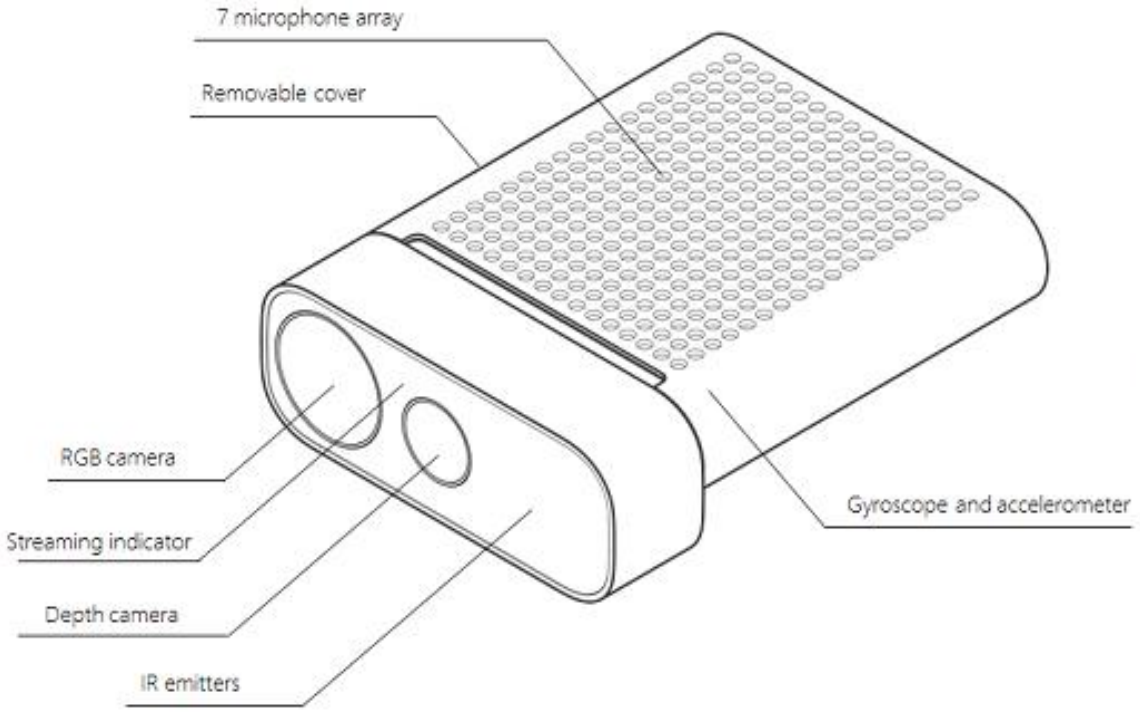
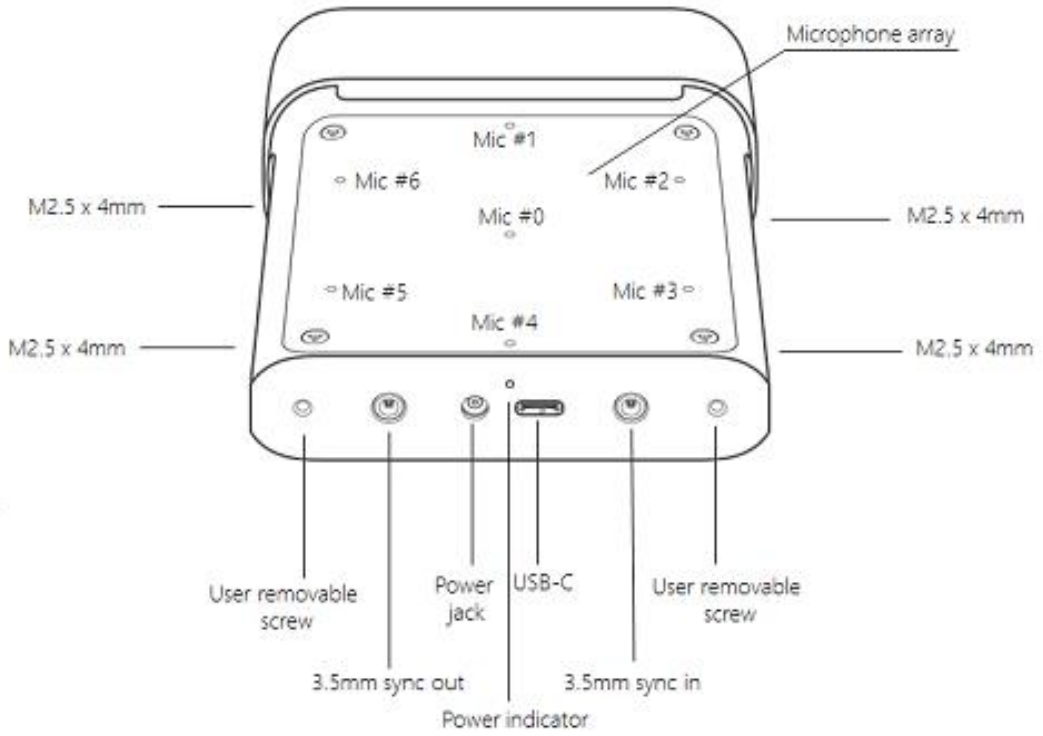
Microsoft Azure Kinect





What is the K4A POR Calibration Node?

- The k4a_por_calibration_node allows a user to update Azure Kinect camera parameters using custom ROS services.
- Node services:
  - k4a_update_exposure
    - Updates exposure time based on a provided value
  - k4a_update_white_balance
    - Updates white balance based on a provided value
  - k4a_auto_tune_exposure
    - Updates exposure time based on a provided target blue value using brute force (original method)
  - k4a_sgd_tune
    - Updates exposure time based on provided target blue, green, red, and white values using stochastic gradient descent

Where are these target values coming from?

- https://gitlab.com/plusone-robotics/product/product_tools.git
  - sgd_data
- sgd_target.py takes all of the images from the provided target folder and averages the blue, green, and red values from the bgr, and averages the the white values from the l channel of hls images. This data is ultimately collected and placed in a Pandas DataFrame and then converted to a csv and saved (average_bgrw.csv). Then the mean and standard deviation for each color channel overall is calculated and saved into another csv (target.csv). The program writes these target values into a text file (rosservice_call.txt) that allows for quick copy-pasting into the terminal when calling k4a_sgd_tune.
- In the future these target values will be calculated from a series of pilot images unique to each site.
- For testing purposes I ran this script on the representative_sample_depal image data.

How does this node work?

- The k4a_por_calibration_node utilizes dynamic reconfigure options in k4a_ros_device.cpp.
- Service error checking:
  - K4aStandardizeExposure
    - Azure Kinect has 13 allowable exposure values
  - K4aCameraExposureUpdateCheck
    - Checks to see if the camera updated its exposure time properly when requested
  - K4aCameraExposureBoundsCheck
    - Checks to see if the requested exposure is within appropriate bounds
  - K4aCameraWhiteBalanceUpdateCheck
    - Checks to see if the camera updated its white balance properly when requested
  - K4aCameraWhiteBalanceBoundsCheck
    - Checks to see if the requested white balance is within appropriate bounds
  - K4aImagePopulatedCheck
    - Confirms that the camera is receiving and properly converting the live feed into a cv::Mat
- Testing suite

Why is tuning the Kinect valuable?

- The Azure Kinect is a powerful camera that will be useful for depalletization in the future.
- This node will provide the foundation for more efficient automation with regard to camera setting calibration.

What could be improved?

- The Kinect has more configurable settings. The node could be expanded to allow for more tuning options.
  - Exposure time, white balance, brightness, contrast, saturation, sharpness, gain
- There is no pilot tuning functionality. Users must input their desired blue/bgrw values for the current services to work.
- The SGD algorithm is not as robust as it could be, and focuses on local rather than global minima when calculating errors. It also only currently focuses on updating exposure time. Error for the standard deviation of values could also be used to calculate forward steps.

What have I learned this summer?

- ROS
  - Writing a ROS node
  - Creating custom messages
  - Creating custom services
  - Writing callbacks
- More in depth C++ programming
  - Industry standards for coding including documentation
  - Writing for catkin builds
  - Reviewing critical sections and mutex locks
- Working with a professional team
  - Asking for help with technical issues
  - More experience using GitLab and GitHub

Summary

- This node allows the user to adjust Azure Kinect camera parameters via the command line, either manually or automatically to match a desired value.
- The Azure Kinect POR calibration node is valuable because it allows for automating the exposure calibration process for the camera. I hope that it will make a good foundation for further automation programming with the Azure Kinect.
- Thank you for this opportunity and I have enjoyed working with you all and Plus One!

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Questions

Sources

- https://learn.microsoft.com/en-us/azure/Kinect-dk/hardware-specification