# Comparison of old and new KIPR Sensors

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***Abstract*—Sensors are very important parts used in Botball® competitions or robotics in general. In 2017, KIPR concluded to provide a new set of sensors to be used in Botball® competitions. Visually, the changes are minor and unnoticeable. In order to find out more about the technical differences between the older and newer models, we conducted a series of experiments using both the older and the newer sensors in appropriate test scenarios to find out more about the new model's advantages and/or disadvantages. Overall, the newer models have a larger dynamic range and therefore provide more precise results.**

## I. Introduction

Sensors provide an easy and fast way of gathering and accessing information about the world around the robot. The 2018 electronics kit provides the user with a variety of different sensors for different applications:

- ET Sensor
- Tophat Sensor
- Small Tophat Sensor
- Light Sensor
- Linear Slide Sensor
- Lever Sensor
- Small Touch Sensor
- Large Touch Sensor

The new versions of these sensors are also available for purchase seperately at the Botball Online Store [1]. We have performed tests on the Tophat, Light, ET and Lever sensor, and will present our results in this publication, which is structured as follows: Section II contains the visual inspection between each sensors new and old version, while Section III adresses the technical differences between the both generations.

## II. Visual Inspection

The visual differences between the sensor generations are mostly minor, although it can be noticed that the older generation sensors use grey cables while the newer ones use red, black and white to resemble the electric poles.

### A. Tophat Sensor

Out of all sensors, the newer tophat sensor clearly shows the biggest visual difference compared to it's predecessor. Instead of being permanently glued to the connection cord, the top of the sensor was placed on a mounting board, which makes the attachment easier and more secure. Because the cable is now plugged into the jack on the board, it can be easily removed or replaced. The old and new version can be seen in Fig. 1.

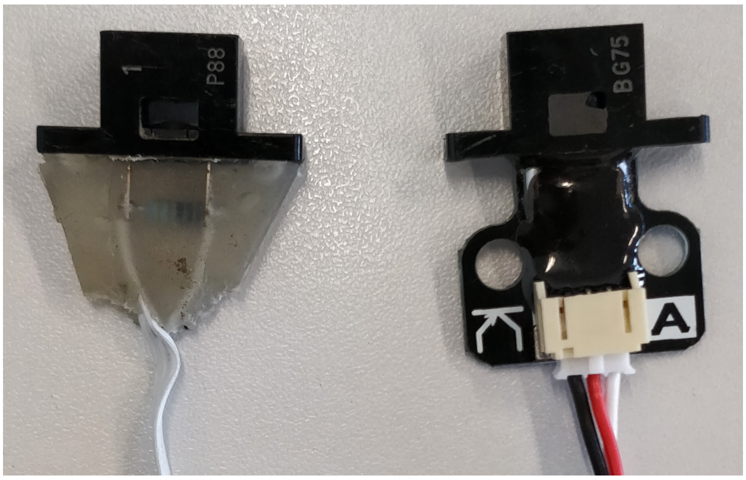


Fig. 1. While the old sensor on the left uses grey cables and doesn't provide an easy way for attachment, the new sensor features a mounting board and a jack for attaching the connector cables.

### B. Light Sensor

Similar to the Tophat Sensor above, the newer version of the Light Sensor was fitted with a mounting board, which again makes attaching the sensor and replacing the connector much easier and faster. Both versions can be seen in Fig. 2.

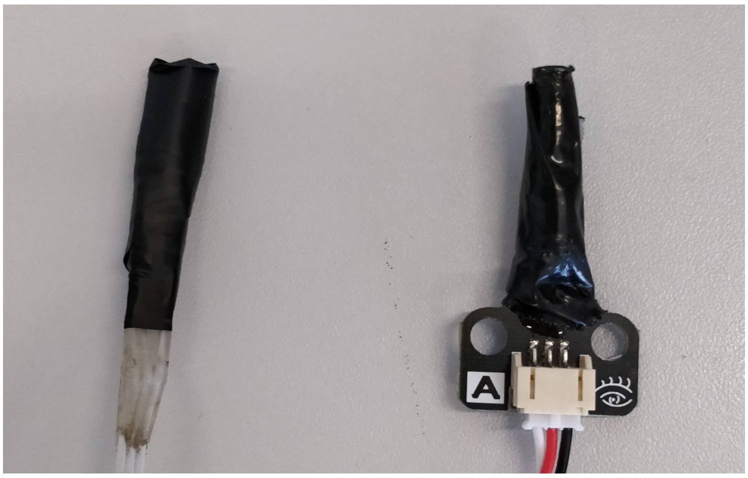


Fig. 2. The old light sensor on the left is missing the mounting board and attachment jack, while the new model on the right features both.

### C. ET Sensor

Contrary to the last two sensors, the ET Sensor doesn't show any differences on the exterior except for the differently colored wires. The older version already featured mounting holes and a wire jack, which can also be seen in Fig. 3.

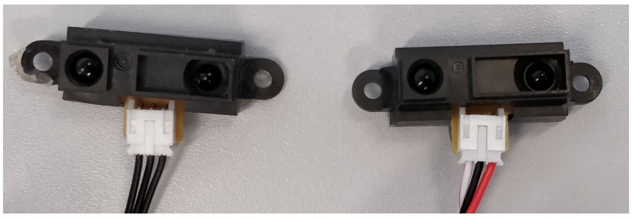

Fig. 3. The old model on the left doesn't show any differences to the new model on the right except for the differently colored connection cable.

### D. Lever Sensor

While the older sensor's casing was colored completely white, the newer sensor was colored black and red, following the new design criteria. The sensor's pins were enclosed in a socket instead of being covered with glue, which saves a lot of space and makes the connector more flexible. The difference can be seen in Fig. 4.

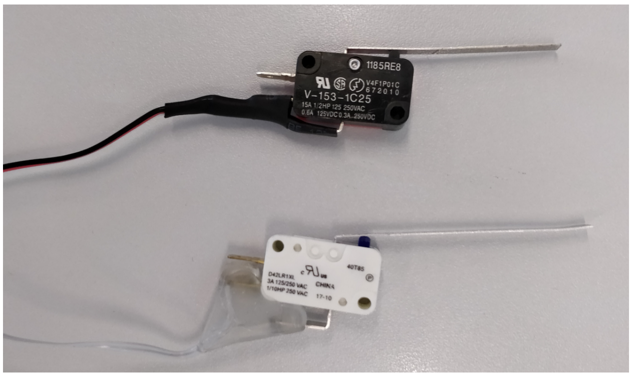


Fig. 4. While the old model at the bottom has a white casing, the new model at the top has a black and red colored casing and a sleeve for protecting the connection cables.

### E. Camera

As you can take from Fig. 5, the old and the new cameras are completely different models from different manufacturers. The old camera was produced by Ubisoft for the video game "Your Shape", while the newer camera is a standard Logitech C170 Webcam. Both cameras have the same resolution, but the new camera delivers brighter pictures. The new camera is also much bigger than the old model.


Fig. 5. The new camera model can be seen on the left, the old model on the right.

## III. Experiments / Technical Comparison

To further explore the technical advantages/disadvantages of the newer sensor generation, we set up and conducted a series of tests for each of the different sensors, which will be explained in the following subsections. All tests were done under artificial lightning in the same room within 2 hours from each other.

### A. Tophat Sensor

The tophat sensor is an infrared sensor with the purpose of identifying colors. In order to demonstrate the technical changes, we used a greyscale image printed on an A4 sheet of white paper. The greyscale ranges from RGB data 0, 0, 0 to 256, 256, 256 with a difference of 16 between each shade. The sensor was attached to a wallaby battery because it made it easier to move the sensor horizontally while still keeping the desired distance to the greyscale. Both sensors were tested on 1cm and 2cm distance to find out if or how much the operating range was improved. The experiment setup can be seen in Fig. 6. The results for the new sensor can be seen in Fig. 7, the results for the old sensor in Fig. 8. Due to the dramatical difference in the dynamic behaviour of the new compared to the old sensor, the data was not plotted in a single diagram. We think that the reason for the improved performance must be a better LED and photo diode inside the IR Tophat sensor. Unfortunately, we do not have any datasheets for the sensor, hence, we can not prove this assumption.

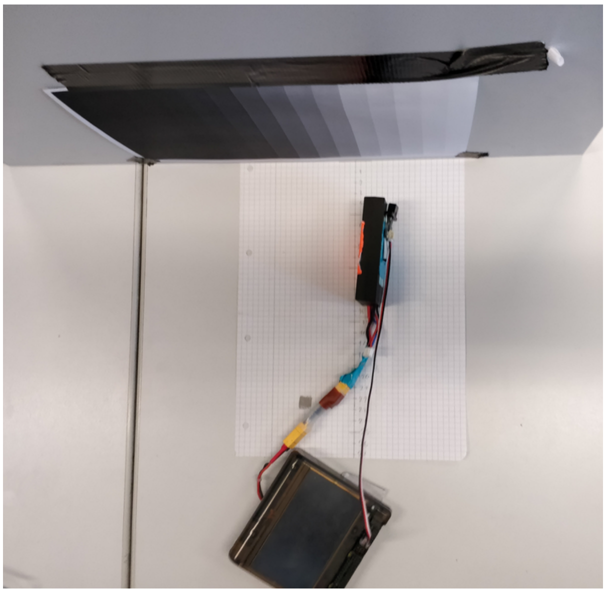

Fig. 6. Our setup for testing the tophat sensor. The sensor was taped to a wallaby battery and connected to the wallaby while being moved across the greyscale.

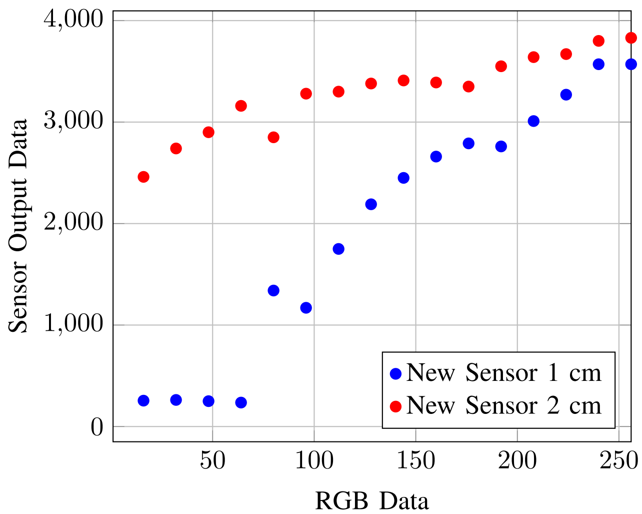


Fig. 7. Graph showing the data for the new tophat sensor at 1 and at 2 cm distance.

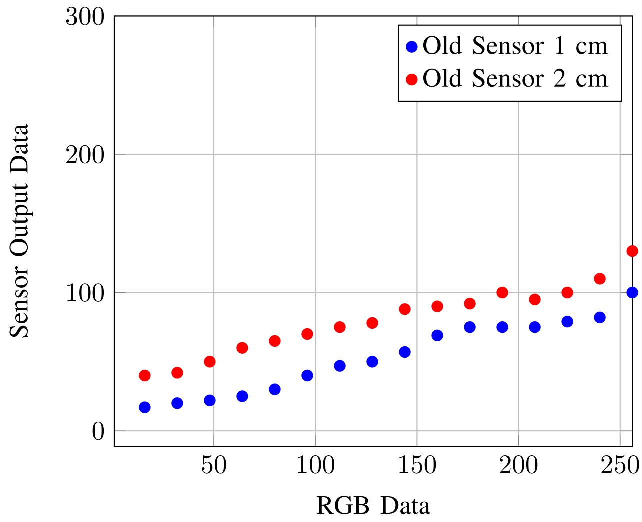


Fig. 8. Graph showing the data for the old tophat sensor at 1 and 2 cm distance.

### B. Light Sensor

While trying to find a suitable way to test the light sensors, we realized that there are only two different situations in which the data depicts major changes, which are under direct light irradiation and under normal lighting. When the newer model is put under extreme lighting, the data rises up to 4000 and then quickly drops to 100 once the source of illumination is removed, whereas the older model returns data of around 200 under normal conditions and then drops down to 0 under direct irradiation.

### C. ET Sensor

The ET Sensor has the unique ability of detecting the sensor's distance to the nearest object by sending out light and interpreting the reflections. We tested this sensor by pointing it at a wall while gradually increasing the distance by 5 cm at a time. It turned out that both sensors lose the ability to precisely determine the distance at about 60 cm far away from the object. The results can be seen in Fig. 9.

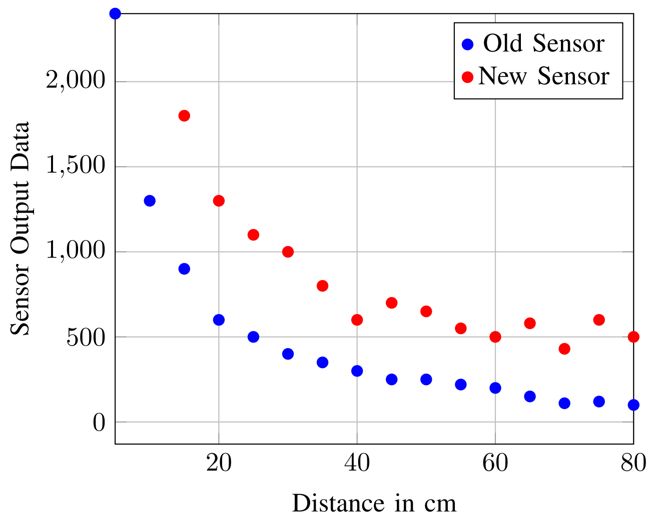


Fig. 9. Graph showing the resulting values for both the new and the old ET sensor

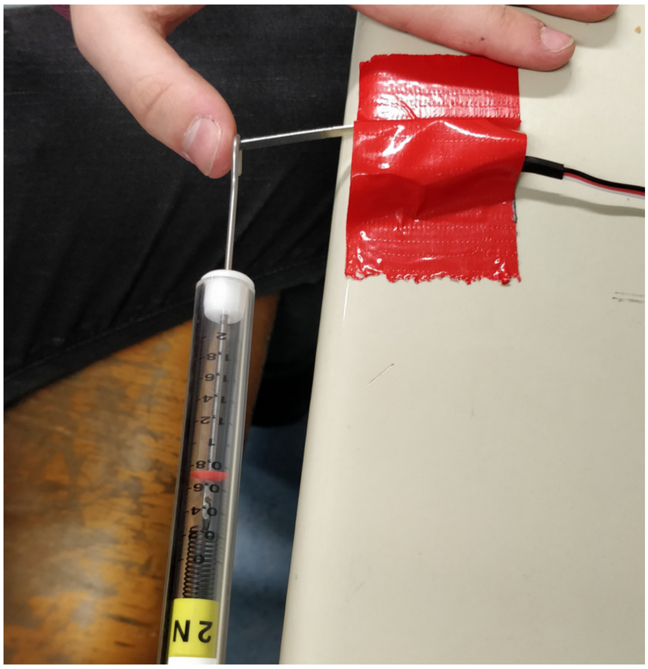


Fig. 11. Our setup for testing the lever sensor. The sensor was taped to the table and connected to a wallaby. We then hooked the spring scale to the lever to test the activation weight.

### *D. Lever Sensor*

For comparing the lever sensor's activation weight, we used two spring scales with a range of 0 - 0.2N and 0 - 2N. We taped the lever sensor to the table with the lever facing sideways so we can easily attach the spring scale's hook to it. We then pulled the scale back until the sensor activated and noted the resulting data. The test setup can be seen in Fig. 11. The activation force data including the corresponding position on the lever can be seen in the table below. While testing, we observed a wide difference between the new and old generation. We think this may be the case due to mechanical wear, considering the older models were used way more than their sucessors.

| | Sensor 1 New | Sensor 2 New | Sensor 1 Old | Sensor 2 Ol |
|---|---|---|---|---|
| Front | 0,88N | 1,32N | 0,02N | 0,012N |
| Middle | 1,36N | 1,8N | 0,028N | 0,02N |
| Back | Too small | Too small | 0,072N | 0,092N |

Fig. 10. The activation force of the old and the new lever sensor with the corresponding position of the

### *E. Camera*

The camera is an important part because it has the ability of detecting objects by their color and telling the user how many objects there are and how big each of them is. To determine which improvements were made in the new version, we decided to take the same picture with both of the cameras and then compared the results. The old camera's image can be seen in Fig. 12, the new one's in Fig. 13. Notice that both pictures were taken within less than 10 minutes of each other, under the same lightning conditions and with the same distance from the object. Fig. 13 is much brighter, with a richer contrast than Fig. 12. This means that details in the shadows and highlights of an image would be lost with the older camera [4].

Fig. 12. Image Output of the old camera

Fig. 13. Image Output of the new camera

## IV. Conclusion

The new sensors offer a larger dynamic range and therefore provide more precise results, where the new sensors do not saturate as fast as the old ones [5]. Most new sensors feature a lego mount, which is a much-needed improvement because a lot of robots are constructed with lego parts. The old lever sensors activation force decreases dramatically after prolonged use. As displayed in Fig. 10, the old sensor, which was in use for over three years just needs an activation force of less than 0.2 N instead of more than 1N on the new levers. The higher activation force of the lever sensor is a very important change because the old sensors were often triggering too early. The dynamic range of the tophat sensor was increased, therefore the data provided by the sensor was made more precise. The new tophat sensor's dynamic range is also steeper than the old one's, which is a helpful improvement because it makes it easier to discriminate between colors. The ET sensor's dynamic range wasn't increased, although the new sensor shows a small offset, which can easily be compensated through calibration. The new camera provides a brighter image with a richer contrast than the old one, which improves the camera's detecting ability in environments with poor lightning.

## Acknowledgements

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