35. Color tracking

35.1. Introduction

35.1.1. Color recognition

The color recognition function can identify multiple colors at any time, independently store the currently recognized color, and detect the color in real time. It can also realize the function of real-time control of HSV. By adjusting the high and low thresholds of HSV, interference colors are filtered out, so that color blocks can be ideally identified in complex environments.

- Introduction to HSV

  HSV (Hue, Saturation, Value) is a color space created by A. R. Smith in 1978 based on the intuitive characteristics of color, also known as the Hexcone Model.

  The parameters of color in this model are: hue (H), saturation (S), and lightness (V).

  H: 0 — 180

  S: 0 — 255

  V: 0 — 255

  Here some reds are classified into the purple range:

	黑	灰	白	红		橙	黄	绿	青	蓝	紫
H_min	0	0	0	0	156	11	26	35	78	100	125
H_max	180	180	180	10	180	25	34	77	99	124	155
S_min	0	0	0	43		43	43	43	43	43	43
S_max	255	43	30	255		255	255	255	255	255	255
V_min	0	46	221	46		46	46	46	46	46	46
V_max	46	220	255	255		255	255	255	255	255	255

- HSV hexagonal pyramid
  - Hue H

    Represents color information, that is, the position of the spectral color. This parameter is represented by an angle, with a value ranging from 0° to 360°, starting from red and counting in counterclockwise direction. Red is 0°, green is 120°, and blue is 240°. Their complementary colors are: yellow is 60°, cyan is 180°, and purple is 300°.

  - Saturation S

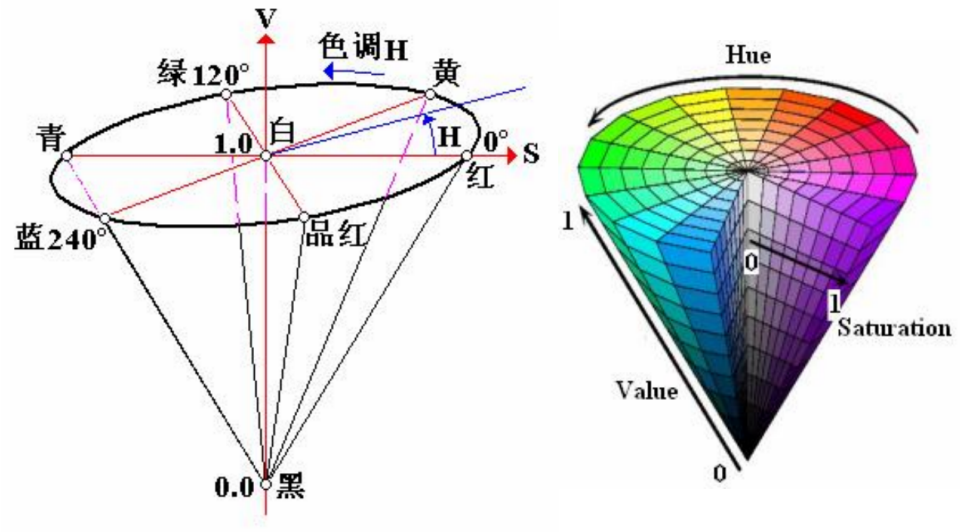
    Saturation S is expressed as the ratio between the purity of the selected color and the maximum purity of that color. When S=0, there is only grayscale. 120 degrees apart. Complimentary colors are 180 degrees apart. A color can be thought of as the result of mixing a certain spectral color with white. The greater the proportion of spectral colors, the closer the color is to spectral colors, and the higher the saturation of the color. The saturation is high and the color is deep and vivid. The white light component of the spectral color is 0, and the saturation reaches the highest level. Usually the value range is 0% ~ 100%. The larger the value, the more saturated the color.

  - Value V

    Brightness represents the brightness of a color. For light source color, the brightness value is related to the brightness of the luminous body; for object color, this value is related to the transmittance or reflectance of the object. Usually the value range is 0% (black) to 100% (white). One thing to note: there is no direct relationship between it and

light intensity.

The three-dimensional representation of the HSV model evolves from the RGB cube. If you imagine looking from the white vertices of the RGB along the diagonal of the cube to the black vertices, you can see the hexagonal shape of the cube. The hexagonal borders represent color, the horizontal axis represents purity, and lightness is measured along the vertical axis.



35.1.2. Brief description of Opencv object tracking algorithm

Object tracking is to locate an object in consecutive video frames. This definition sounds straightforward, but in computer vision and machine learning, tracking is a very broad term that encompasses conceptually similar but technically different concepts. For example, the following are all different but related ideas commonly studied under object tracking:

- Dense Optical flow DOF: These algorithms help estimate the motion vector of each pixel in a video frame.
- Sparse optical flow: For example, the Kanade-Lucas-Tomashi (KLT) feature tracking algorithm tracks the positions of several feature points in the image.
- Kalman Filtering: A very popular signal processing algorithm based on prior motion information, used to predict the position of moving targets. One of the early applications of this algorithm was in missile guidance! The onboard computer that guided the Apollo 11 lunar module to the moon had a Kalman filter.
- Meanshift and Camshift: These are algorithms for locating the maximum value of the density function, they are also used for tracking.
- Single object trackers: In this type of trackers, the first frame is marked with a rectangle to indicate the location of the object to be tracked. The object is then tracked in subsequent frames using a tracking algorithm. In most real-world applications, these trackers are used together with object detectors.
- Multiple object track finding algorithms: When we have a fast object detector that detects multiple objects in each frame, and then runs a track finding algorithm to identify which rectangle in a frame corresponds to It makes sense to correspond to the rectangle in the next frame.
- OpenCV Tracking API

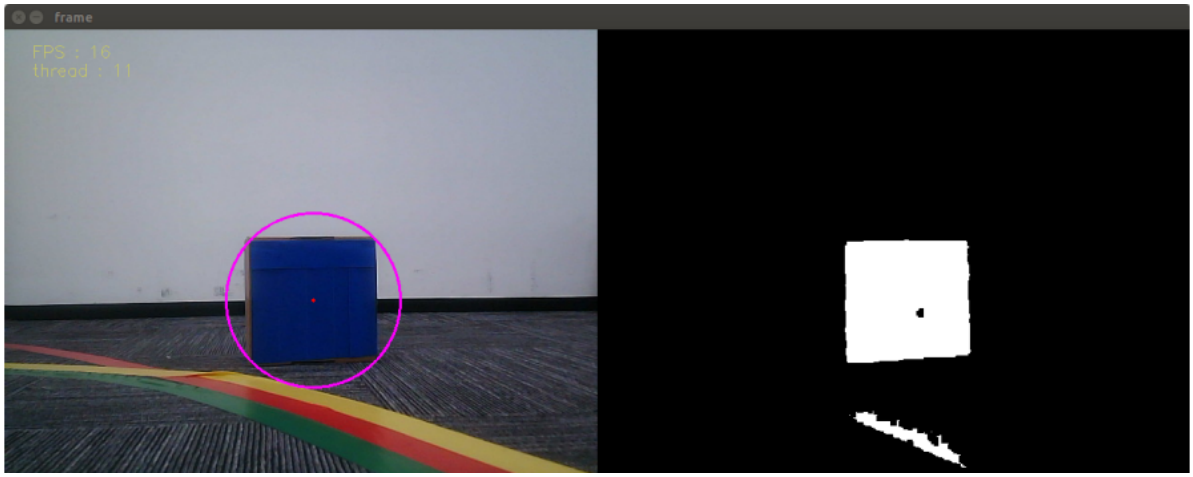
算法	速度	精度	描述
BOOSTING	慢	差	和Haar casades（AdaBoost）背后所用的机器学习算法相同， 但是具其诞生已有十多年了，元老级算法。
MIL	慢	差	比BOOSTING更精准，但是失败率比较高。
KCF	快	高	比BOOSTING和MIL都快，但是在有遮挡的情况下表现不佳。
TLD	一般	一般	误报非常多，跟串现象严重。
MEDIANFLOW	一般+	一般	误报很少，对于快速跳动或者快速移动的物体，模型会失效。
GOTURN	一般	一般	深度学习为基础的目标检测器，它需要额外的模型才能运行。
MOSSE	最快	高-	速度真心快，但是不如CSRT和KCF的准确率那么高，如果追求速度可以选择它。
CSRT	快-	最高	比KCF稍精确，但速度不如KCF。

35.2. Start

```
roslaunch astra_tracker AstraTracker.launch VideoSwitch:=false
tracker_type:=color
```

- tracker_type parameter: select the tracking algorithm ['BOOSTING', 'MIL', 'KCF', 'TLD', 'MEDIANFLOW', 'MOSSE', 'CSRT', 'color'], and click the [F] key on the keyboard after starting Switchable.

After startup, the system defaults to [Target Detection Mode], as shown below:



[r]: Color selection mode, you can use the mouse to select the area of the color to be recognized (cannot exceed the area range)

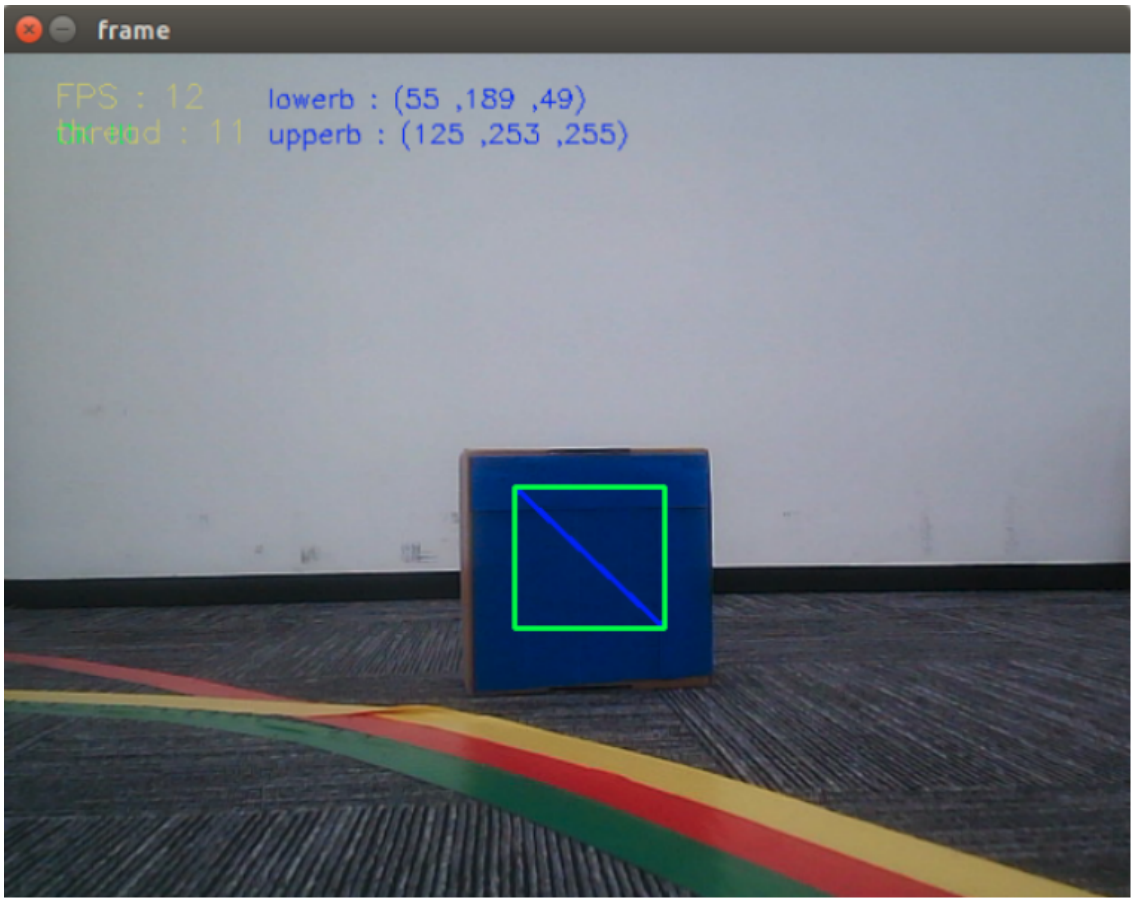
【i】: Target detection mode. Color image on the left (Color), binary image on the right (Binary)

[f]: Switching algorithm: ['BOOSTING', 'MIL', 'KCF', 'TLD', 'MEDIANFLOW', 'MOSSE', 'CSRT', 'color']

【q】: Exit the program

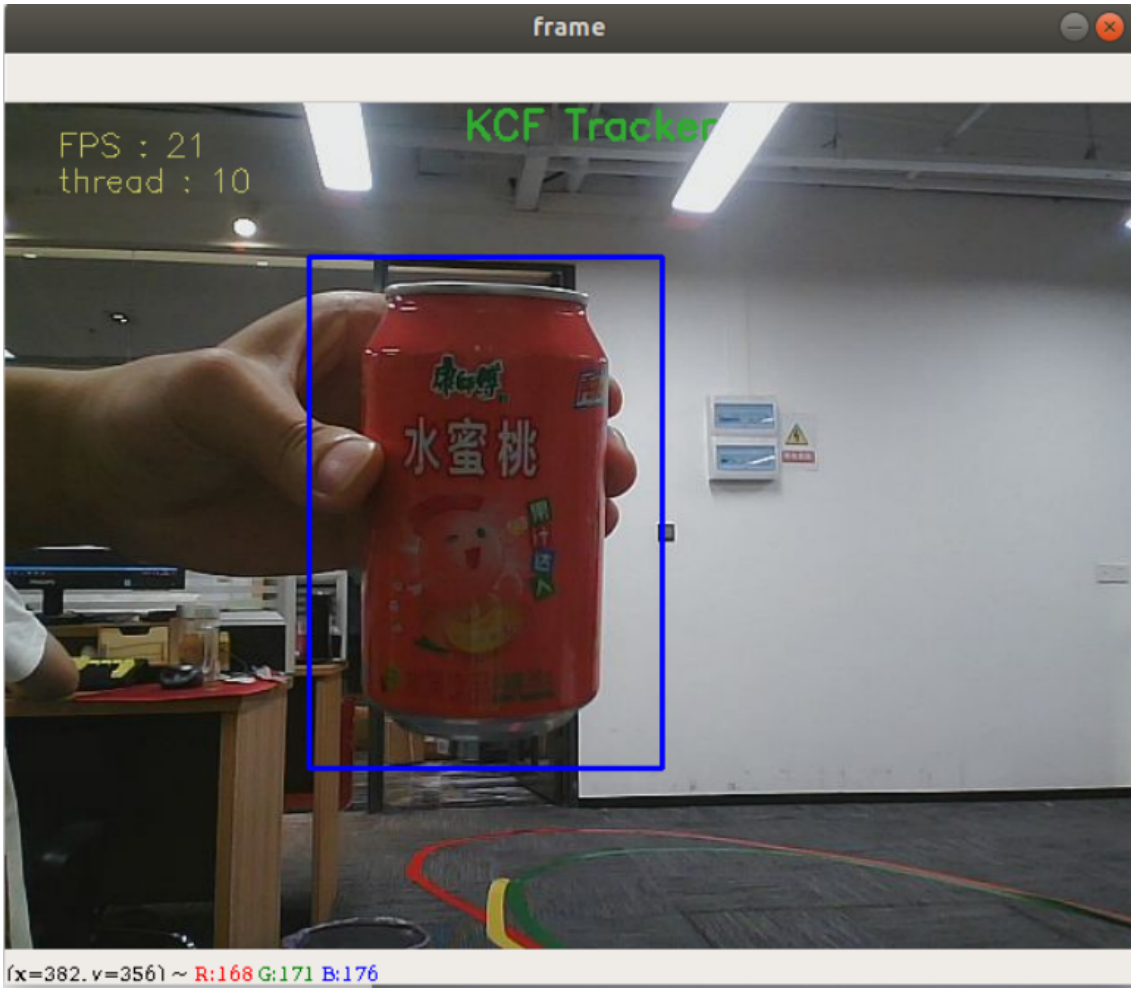
- Color recognition

  In the color selection mode, use the mouse to select the location of the colored object, as shown in the figure below, and release it to start recognition.



- Object tracking

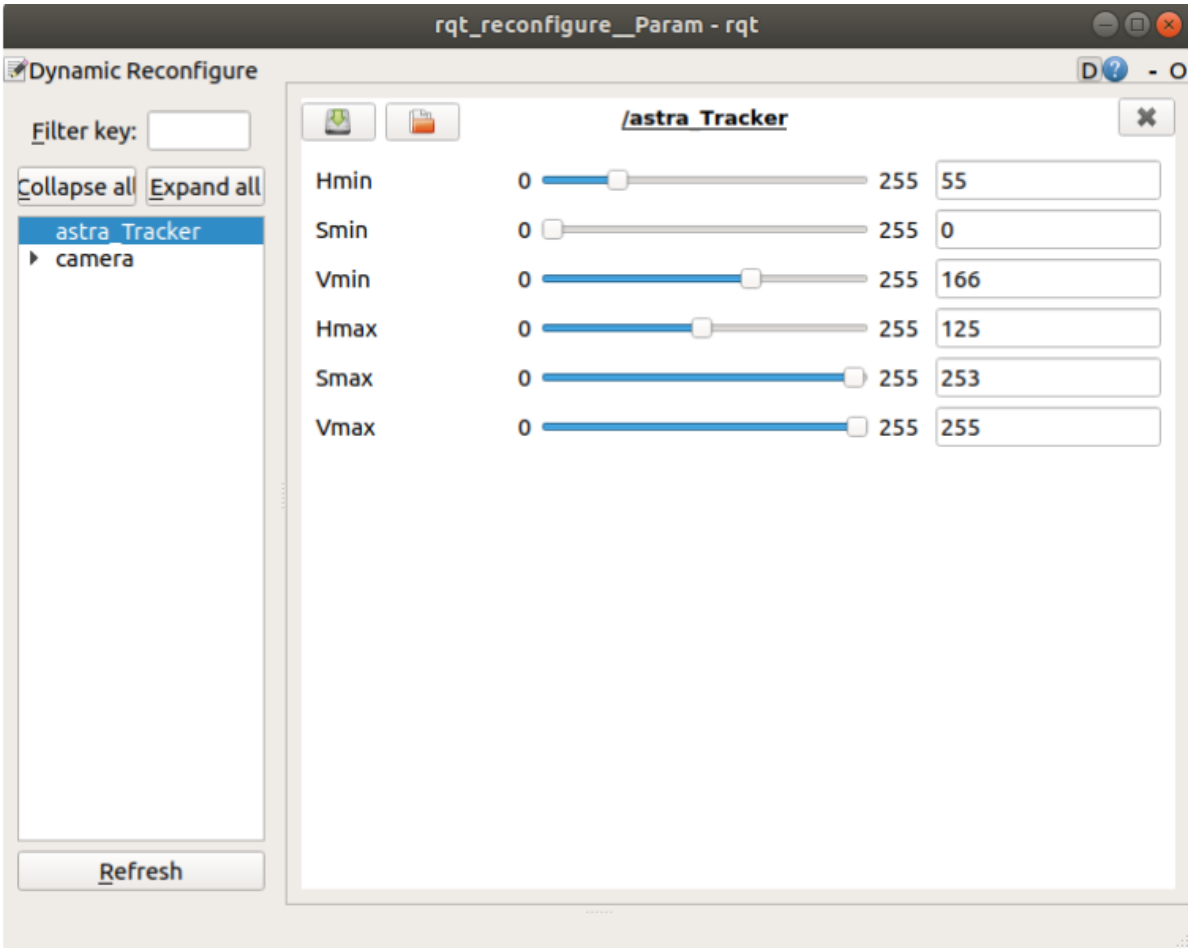
  After starting, enter the selection mode, use the mouse to select the location of the object, as shown in the figure below, release it to start recognition.



35.3. Color calibration

Dynamic parameter settings,

```
rosrun rqt_reconfigure rqt_reconfigure
```



Select the [astra_Tracker] node. Generally, you only need to adjust [Hmin], [Smin], [Vmin], and [Hmax]. These four parameters can be easily identified. The slide bar is always in a dragging state and data will not be transferred to the system until it is released; you can also select a row and then slide the mouse wheel.