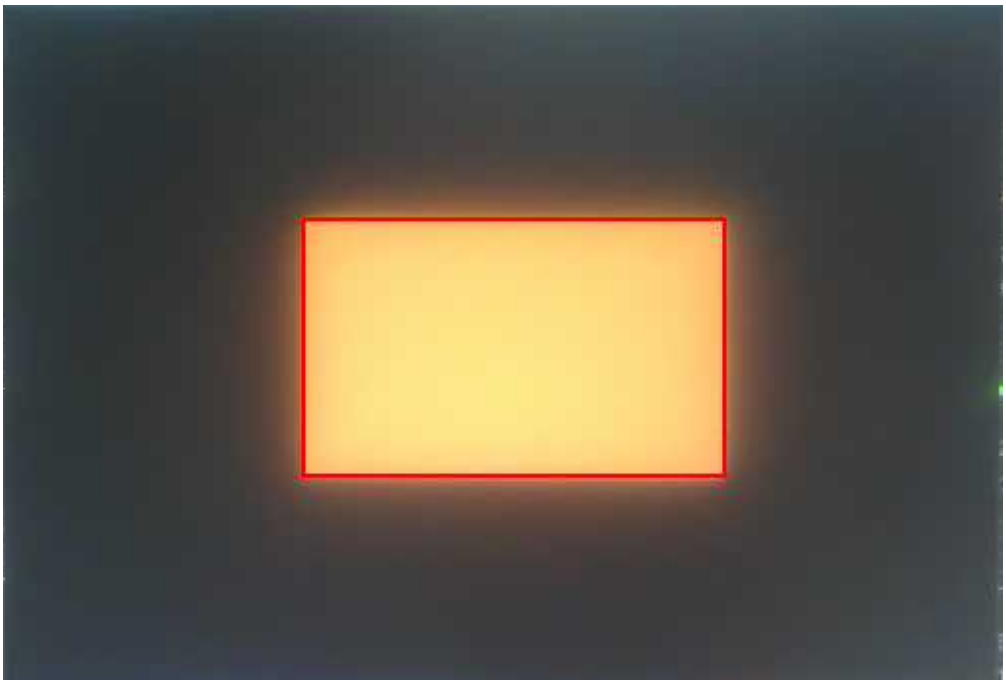
Rectangle Recognition - Color Image

Example Results

Run this section's example code [Source Code /06.cv_lite/8.rgb888_find_rectangles.py]

In this section, we will use the `cv_lite` extension module to implement rectangle detection in RGB888 format on an embedded device.



Code Overview

Importing Modules

```
import time, os, sys, gc
from machine import Pin
from media.sensor import * # Camera interface
from media.display import * # Display interface
from media.media import * # Media manager
import _thread
import cv_lite # cv_lite extension module
import ulab.numpy as np
```

Setting the Image Size

```
image_shape = [480, 640] # Height x Width
```

Define the image resolution to 480x640 (height x width). The camera and display modules will be initialized based on this size.

Initialize the camera (RGB888 format)

```
sensor = Sensor(id=2, width=1280, height=960, fps=90)
sensor.reset()
sensor.set_framesize(width=image_shape[1], height=image_shape[0])
sensor.set_pixformat(Sensor.RGB888) # Set RGB888 pixel format
```

- Initialize the camera, set the resolution to 1280x960 and the frame rate to 90 FPS.
- Resize the output frame to 640x480 and set it to RGB888 format (three-channel color image, suitable for rectangle detection in color images).

Initialize the display module

```
Display.init(Display.ST7701, width=image_shape[1], height=image_shape[0],
to_ide=True, quality=50)
```

Initialize the display module, using the ST7701 driver chip, with a resolution consistent with the image size. `to_ide=True` indicates that the image will be simultaneously transmitted to the IDE for virtual display, and `quality=50` sets the image transmission quality.

Initialize the media manager and start the camera

```
MediaManager.init()
sensor.run()
```

Initialize the media resource manager and start the camera to capture the image stream.

Set rectangle detection parameters

```
canny_thresh1 = 50 # Canny edge detection low threshold
canny_thresh2 = 150 # Canny edge detection high threshold
approx_epsilon = 0.04 # Polygon approximation precision (ratio)
area_min_ratio = 0.001 # Minimum area ratio (0-1)
max_angle_cos = 0.5 # Maximum angle cosine (smaller, closer to rectangle)
gaussian_blur_size = 5 # Gaussian blur kernel size (odd number)
clock = time.clock() # Start FPS timer
```

- `canny_thresh1`: The lower threshold for Canny edge detection, used to control the detection of weak edges.
- `canny_thresh2`: The upper threshold for Canny edge detection, used to control the detection of strong edges. A larger value results in fewer edges being detected.
- `approx_epsilon`: The polygon fitting accuracy ratio. A smaller value results in more accurate fitting, but increases the computational effort.
- `area_min_ratio`: The minimum area ratio relative to the total image area, used to filter out rectangles that are too small.
- `max_angle_cos`: The maximum angle cosine. A smaller value results in shapes that are closer to rectangles.
- `gaussian_blur_size`: The Gaussian blur kernel size. Used for image preprocessing to reduce noise. Must be an odd number.
- `clock`: Used to calculate the frame rate.

Image Processing and Rectangle Detection

```
while True:
    clock.tick()

    # Capture current frame
    img = sensor.snapshot()
    img_np = img.to_numpy_ref() # Get RGB888 ndarray reference

    # Call underlying rectangle detection function, returns list of rectangles
[x0, y0, w0, h0, x1, y1, w1, h1, ...]
    # Call underlying rectangle detection function, returns list of rectangles
[x, y, w, h, ...]
    rects = cv_lite.rgb888_find_rectangles(
        image_shape, img_np,
        canny_thresh1, canny_thresh2,
        approx_epsilon,
        area_min_ratio,
        max_angle_cos,
        gaussian_blur_size
    )

    # Iterate detected rectangles and draw bounding boxes
    for i in range(0, len(rects), 4):
        x = rects[i]
        y = rects[i + 1]
        w = rects[i + 2]
        h = rects[i + 3]
        img.draw_rectangle(x, y, w, h, color=(255, 0, 0), thickness=2)
    # Display image with drawn rectangles
    Display.show_image(img)

    # Free temporary variables memory
    del img_np
    del img

    # Perform garbage collection
    gc.collect()

    # Print current FPS and number of detected rectangles
    print("fps:", clock.fps())
```

- **Image Capture**: Acquire an image frame using `sensor.snapshot()` and convert it to a NumPy array reference using `to_numpy_ref()`.
- **Rectangle Detection**: Call `cv_lite.rgb888_find_rectangles()` to detect rectangles and return a list of detected rectangle information (each rectangle occupies 4 elements: `[x, y, w, h]`, i.e., the coordinates of the upper-left corner, width, and height).
- **Rectangle Drawing**: Iterate over each detected rectangle and draw a red rectangular outline (`color=(255, 0, 0)`) on the image to mark the target area.
- **Image Display**: Display the processed image to the screen or IDE virtual window.
- **Memory Management and Frame Rate Output**: Release temporary variables, call `gc.collect()` to clean up memory, and print the current frame rate using `clock.fps()`.

Resource release

```
sensor.stop()
Display.deinit()
os.exitpoint(os.EXITPOINT_ENABLE_SLEEP)
time.sleep_ms(100)
MediaManager.deinit()
```

Parameter adjustment instructions

- `canny_thresh1`: Low threshold. The smaller the value, the more weak edges can be detected, but it may introduce noise. It is recommended to start adjusting from 50.
- `canny_thresh2`: High threshold. The larger the value, the fewer strong edges are detected. It is suitable for noisy environments. Increasing this value can reduce false edges.
- `approx_epsilon`: Polygon fitting accuracy ratio. The smaller the value, the more accurate the fitting, but the calculation amount increases. It is recommended to adjust it according to the complexity of the image.
- `area_min_ratio`: Minimum area ratio. The larger the value, the more rectangles are filtered out. It is suitable for ignoring small targets. Adjust it according to the target size.
- `max_angle_cos`: Maximum angle cosine. Smaller values result in detected shapes that are closer to rectangles, making it suitable for strictly filtering for rectangles. A starting value of 0.5 is recommended.
- `gaussian_blur_size`: Gaussian blur kernel size. Larger values produce greater image smoothing, but may result in loss of detail. This must be an odd number; 3 or 5 is recommended as a starting point for testing.