KCF

KCF is a High-Speed Tracking with Kernelized Correlation Filters. Here is the paper link.

Henriques J F , Caseiro R , Martins P , et al. High-Speed Tracking with Kernelized Correlation Filters[J]. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2015, 37(3):583-596.

API Introduction

The KCF here was developed in C++. More details about API are introduced below.

```
template <class T>
class KCF
```

This `class KCF` handles the whole object tracking mission. The implementation is simplified to two steps `init(...)` and `update(...)`. Template supports `float` and `double` by now.

```
void init(ArrayReal<uint8_t, T, 3> &image, int x, int y, int width, int height);
```

The inputs are:

- **image**: an image in `ArrayReal<uint8_t, T, 3>` type
- **x**: the x coordinate of target left-up corner
- **y**: the y coordinate of target left-up corner
- **width**: the width of target
- **height**: the height of target

```
struct rectangle_side_t<T> update(ArrayReal<uint8_t, T, 3> &image);
```

The inputs is:

- **image**: a new image in `ArrayReal<uint8_t, T, 3>` type

The output is:

- A `struct rectangle_side_t<T>` type value contains the new position of target

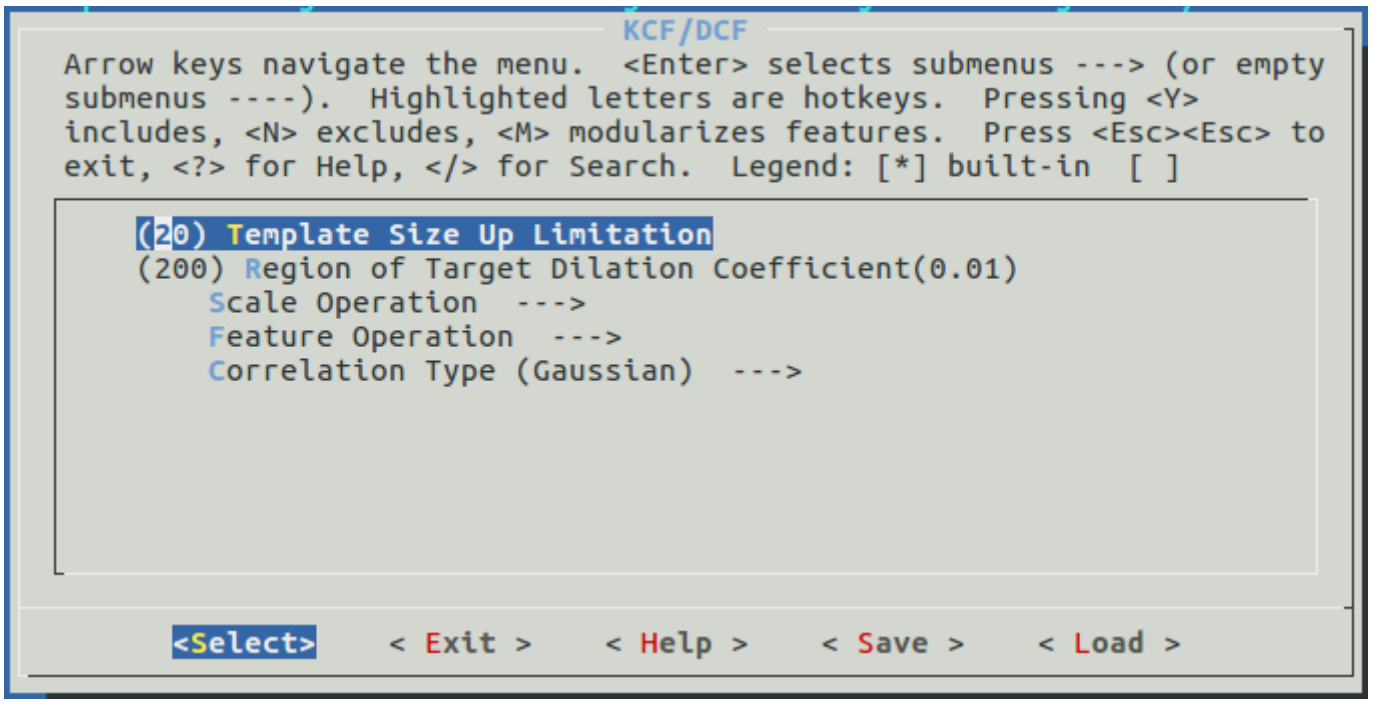
  This structure is defined as follows:

  ```
  template <typename T>
  struct rectangle_side_t
  {
      T x;      // the x coordinate of left-up corner
      T y;      // the y coordinate of left-up corner
      T width;  // the width of rectangle
      T height; // the height of rectangle
  };
  ```

Advance Configuration

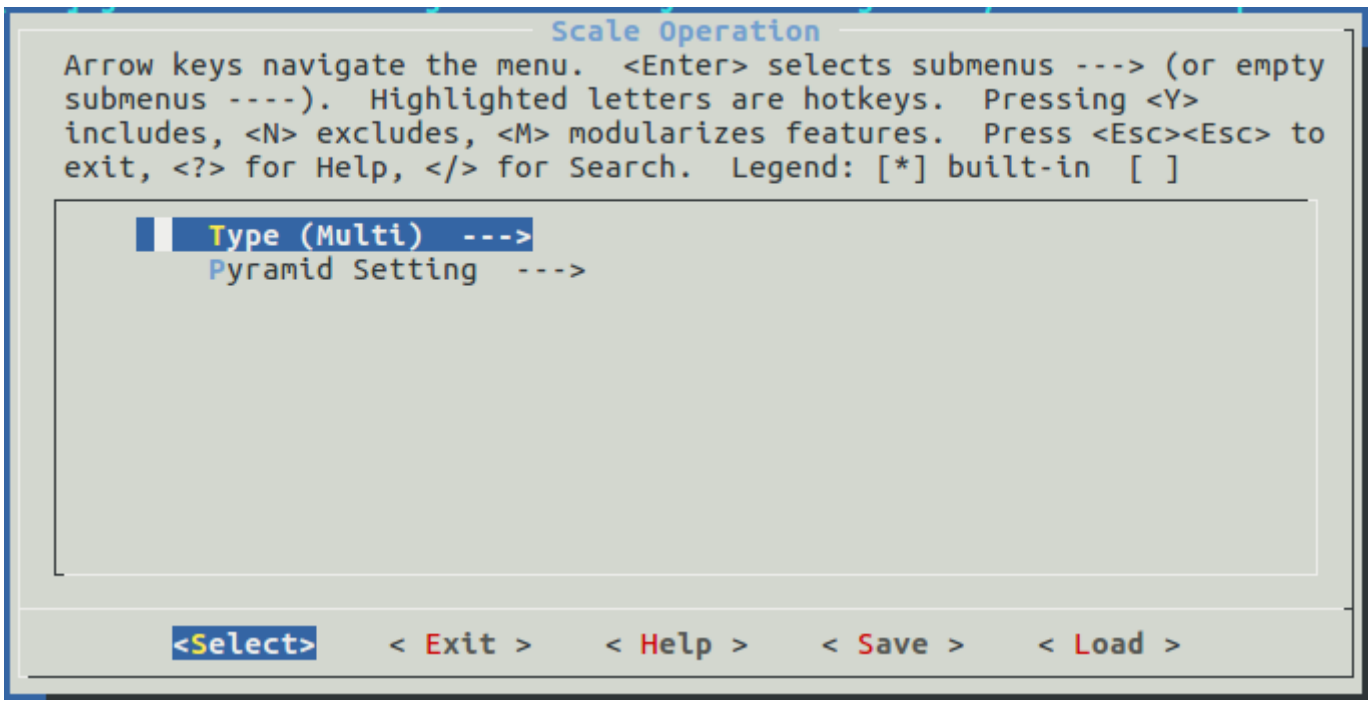
Introduction

Advance configuration could be found in `menuconfig`. Select **Component config** >> **ESP-FACE Configuration** >> **Object Tracking** >> **KCF/DCF** sequentially, you'll see the menu as follow.

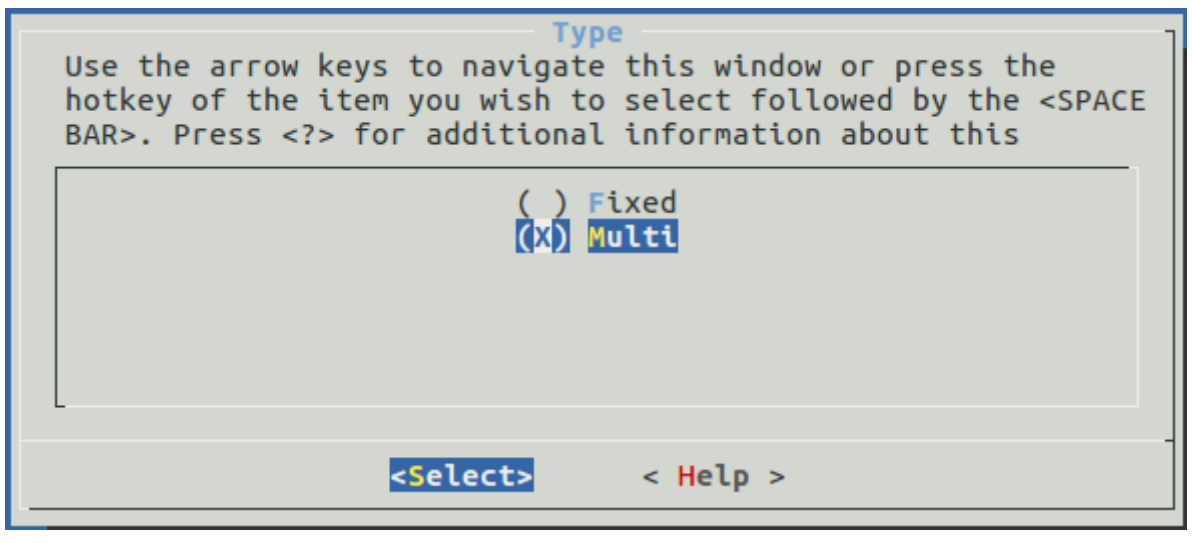


- **Template Size Up Limitation**
  - Range for gray feature: [20, the length of the shortest edge of the original input image)
  - Range for HOG feature: [32, the length of the shortest edge of the original input image)
  - For an original input image of a fixed size, the larger the size
    - the better the performance is;
    - the longer the processing takes
    - and vice versa.
- **Region of Target Dilation Coefficient**
  - The Region of Target × Coefficient × 0.01 = The Region of Interest
  - For an original input image of a fixed size, the larger the coefficient the wider tracking region is, and vice versa.
- **Scale Operation**

  The menu is as follow:



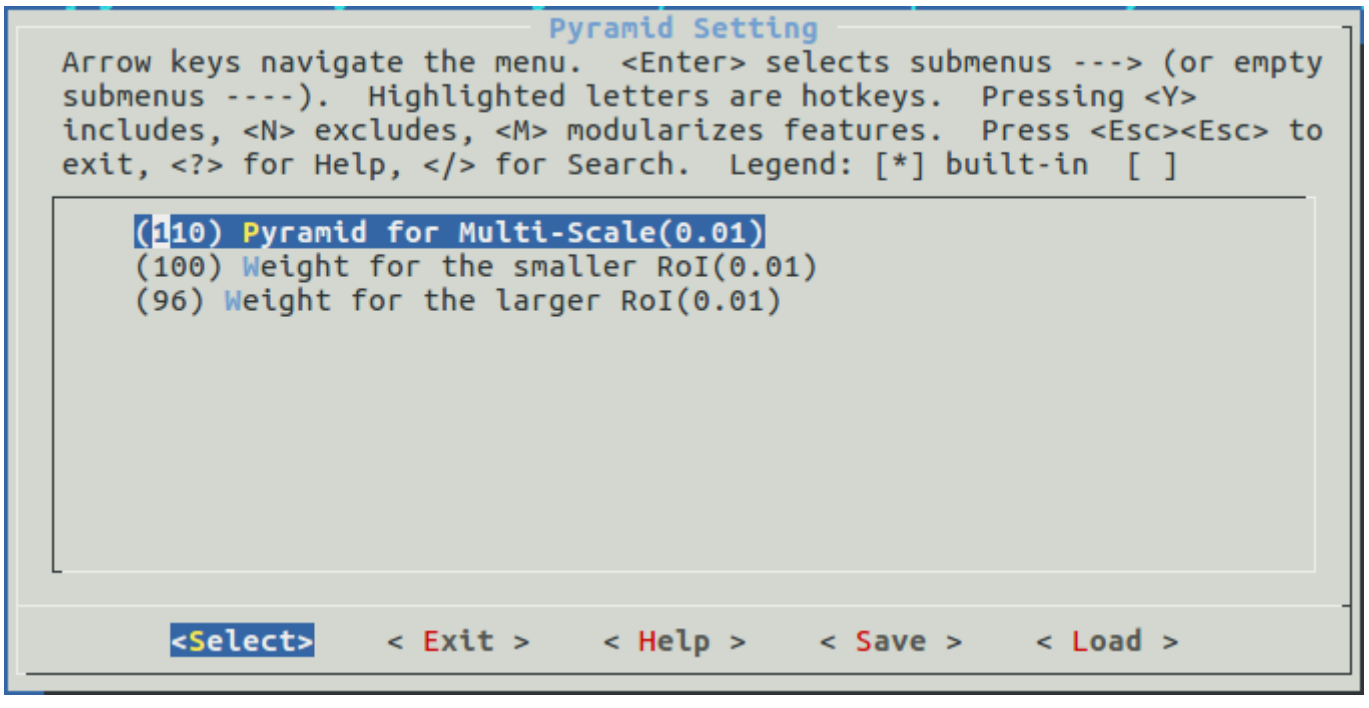
  - **Type**



    The choices are:

    - **Fixed**: the size of RoI is fixed.
    - **Multi**: the KCF will track on the normal RoI, smaller RoI and larger RoI.
  - **Pyramid Setting**

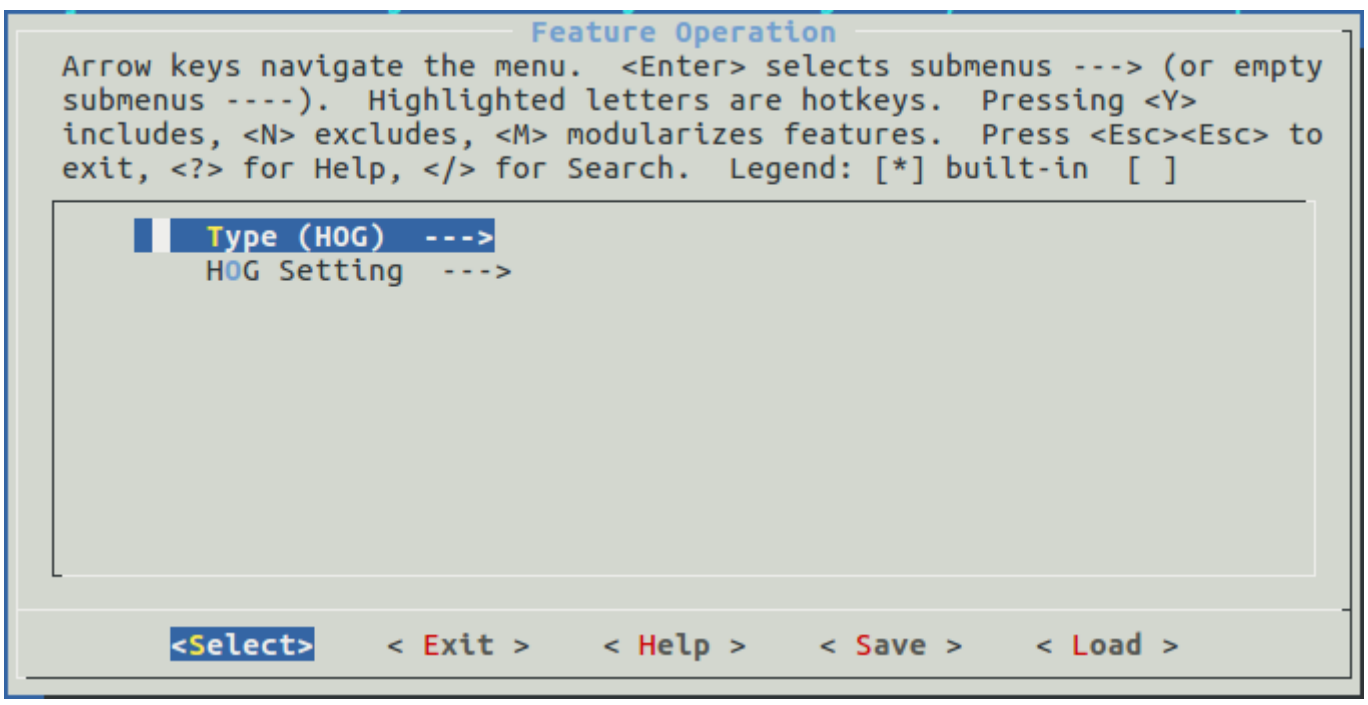
    It is only displayed when type `Multi` is selected. The menu is as follow:



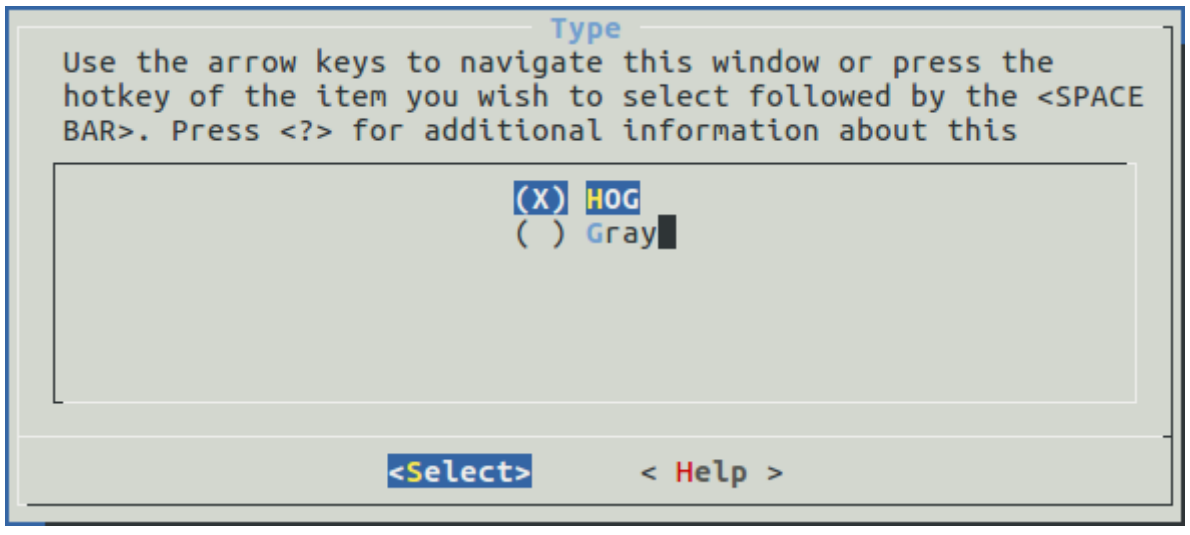
- **Pyramid for Multi-Scale**:
  - the smaller RoI = normal RoI / pyramid / 0.01
  - the larger RoI = normal RoI × pyramid × 0.01
- **Weight for the smaller RoI**
  - the value of the hottest point on the smaller RoI will be multiplied with this weight, then compared with the normal RoI's
  - the larger the weight is, the more sensitive of zooming in is
- **Weight for the larger RoI**
  - the value of the hottest point on the larger RoI will be multiplied with this weight, then compared with the normal RoI's.
  - the larger the weight is, the more sensitive of zooming out is

- **Feature Operation**

  The menu is as follow:



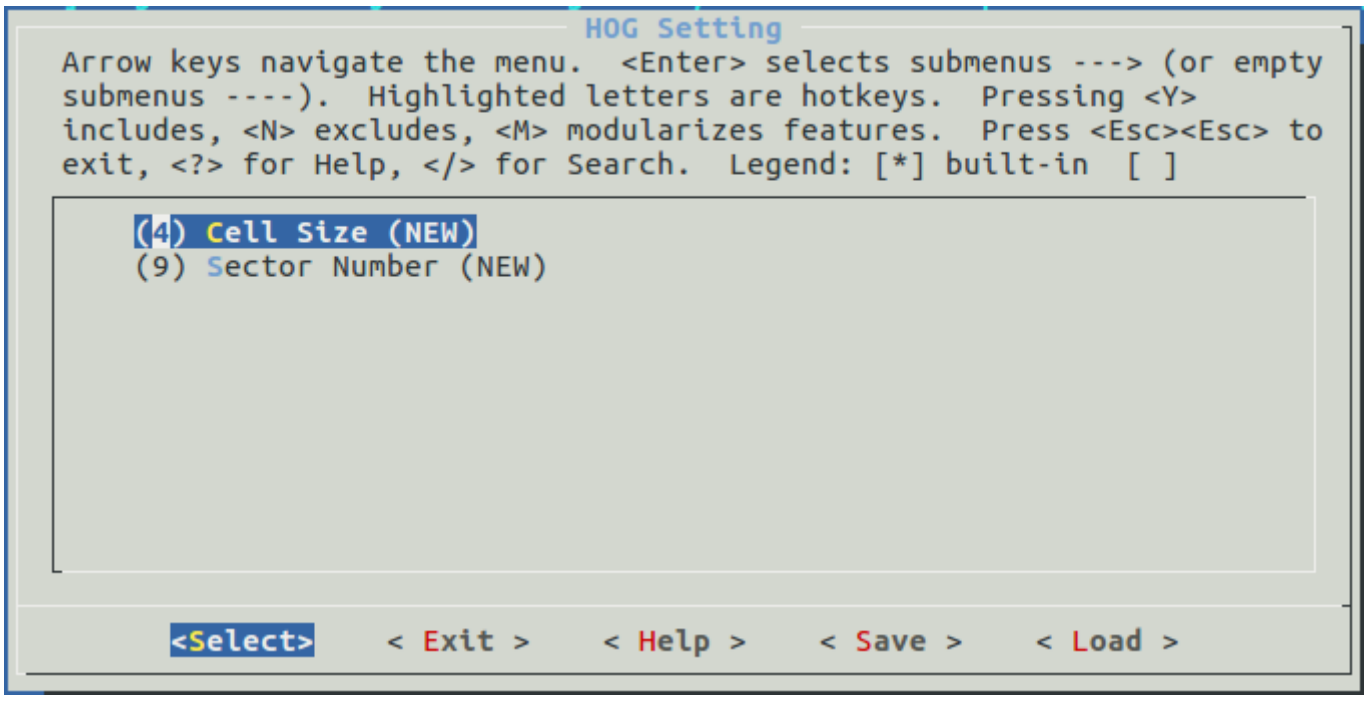
  - **Type**



    The choices are:

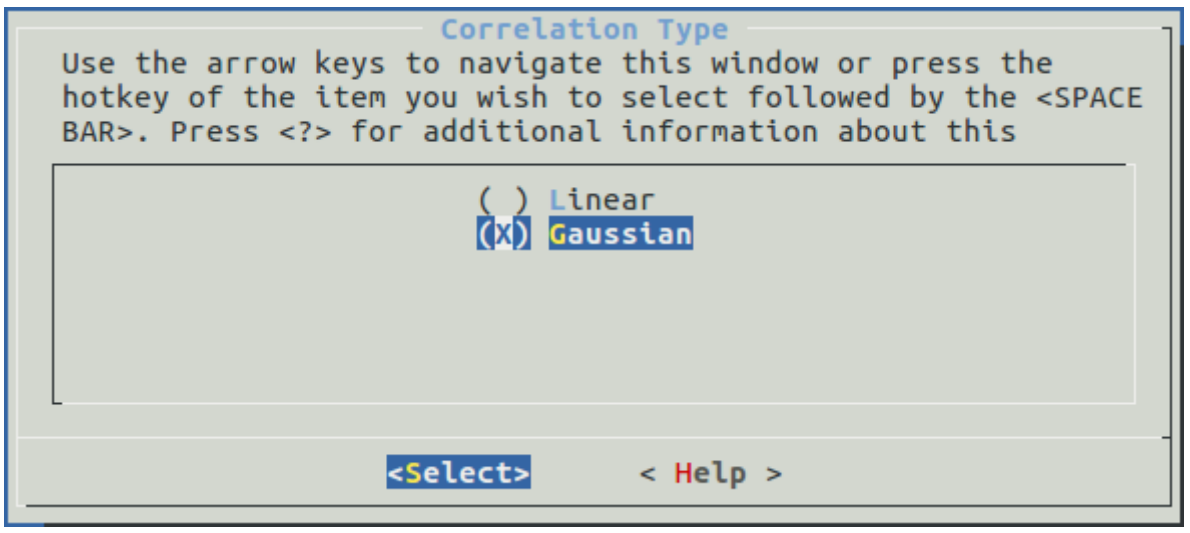
    - **Gray**: choosing Gray as feature
    - **HOG**: choosing HOG of image as feature
  - **HOG Setting**

    It is only displayed when type `HOG` is selected. The menu is as follow:



- **Cell Size**: the size of HOG cell
- **Sector Number**: the number of PI divided

- **Correlation Type**



The choices are:

  - **Linear**: linear correlation
  - **Gaussian**: gaussian correlation

  Gaussian correlation takes more calculation consumption than linear correlation, which means longer processing takes. Although, the tracking success rate is higher.

Setting Guide

The KCF is quite sensitive to environment. Here is the relationship between environment and settings.

Environment	Simple	->	Complicated
Template Size	Small	->	Large
Feature Type	Gray	->	HOG
Scale Type	Fixed	->	Multi

Setting Test

Some fixed settings are:

Hardware	ESP-EYE
Region of Target Dilation Coefficient	300
Pyramid for Multi-Scale	110
Weight for the smaller RoI	110
Weight for the larger RoI	96
HOG Sector Number	9

The tables below show the latency of different settings.

Gray + Fixed + Linear

Template Size	Latency(ms)
12 × 12	11
14 × 14	20
16 × 16	16
20 × 20	25
32 × 32	38
40 × 40	60
48 × 48	109
50 × 50	94
56 × 56	211
64 × 64	220

Gray + Multi + Linear

Template Size	Latency(ms)
32 × 32	76
40 × 40	130
48 × 48	199
50 × 50	200
56 × 56	390
64 × 64	400

Gray + Fixed + Gaussian

Template Size	Latency(ms)
20 × 20	20
32 × 32	67
40 × 40	103
48 × 48	195
50 × 50	185
56 × 56	372
64 × 64	380

Gray + Multi + Gaussian

Template Size	Latency(ms)
20 × 20	38
32 × 32	130
40 × 40	210
48 × 48	390
50 × 50	360
56 × 56	745
64 × 64	720

HOG + Fixed + Linear

Template Size	Cell Size	Latency(ms)
32 × 32	4	73
40 × 40	4	90
48 × 48	4	151
56 × 56	4	281
64 × 64	4	350
50 × 50	5	168
60 × 60	6	215
70 × 70	7	286

HOG + Multi + Linear

Template Size	Cell Size	Latency(ms)
32 × 32	4	126
40 × 40	4	198
48 × 48	4	304
56 × 56	4	538
64 × 64	4	275
50 × 50	5	330
60 × 60	6	420
70 × 70	7	567

HOG + Fixed + Gaussian

Template Size	Cell Size	Latency(ms)
32 × 32	4	132
40 × 40	4	213
48 × 48	4	302
56 × 56	4	546
64 × 64	4	1053
50 × 50	5	179
60 × 60	6	325
70 × 70	7	398

HOG + Multi + Gaussian

Template Size	Cell Size	Latency(ms)
32 × 32	4	252
40 × 40	4	404
48 × 48	4	573
56 × 56	4	1028
64 × 64	4	1982
50 × 50	5	498
60 × 60	6	629
70 × 70	7	770

Setting Example

The tables below show some recommended settings.

Fast Fixed/Multi-Scale

latency(ms)	**20 / 38**
Template Size Up Limitation	20
Region of Target Dilation Coefficient	300
Scale Type	Fixed / Multi
Pyramid for Multi-Scale	110
Weight for the smaller RoI	105
Weight for the larger RoI	95
Feature Type	Gray
Correlation Type	Gaussian

Stable Fixed-Scale

Latency(ms)	**73**
Template Size Up Limitation	32
Region of Target Dilation Coefficient	300
Feature Type	HOG
Cell Size	4
Sector Number	9
Correlation Type	Linear

Stable Multi-Scale

Latency(ms)	**126**
Template Size Up Limitation	32
Region of Target Dilation Coefficient	300
Pyramid for Multi-Scale	110
Weight for the smaller RoI	120
Weight for the larger RoI	96
Feature Type	HOG
Cell Size	4
Sector Number	9
Correlation Type	Linear