Robot Teknolojisine Giriş
BLM4830

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Ders Tanıtım Formu ve Konular

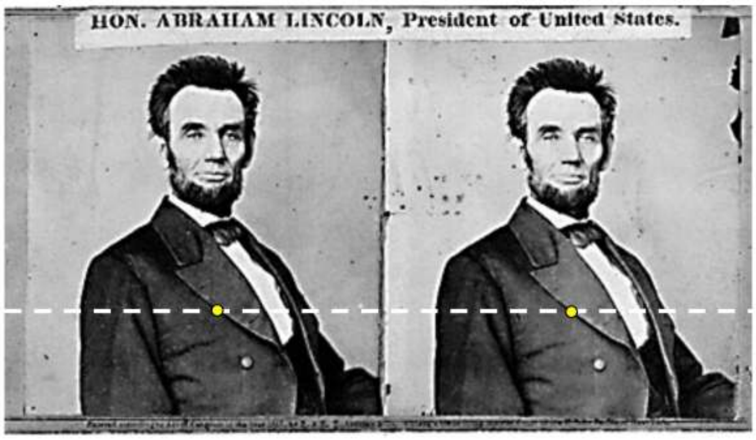
Hafta	Tarih	Konular
1	2.03.2022	Ders Tanıtımı, ROS ve Platform Tanıtımı, Robot Çeşitleri ve Robotik Konuları Başlangıcı
2	9.03.2022	Kinematik - Genel Tanımlar - Diferansiyel Sürüşlü Robot İçin Hesaplama Örnekleri
3	16.03.2022	Sensörler - Çeşitleri ve Çalışma Sistematikleri ve Uygulamaları
4	23.03.2022	Odometri ve Lokalizasyon Kavramları
5	30.03.2022	Haritalama Yöntemleri ve Uygulamaları
6	6.04.2022	Uygulama 1 (Laboratuvar)
7	13.04.2022	Navigasyon Yaklaşımları ve Uygulamaları
8	20.04.2022	Ara Sınav
9	27.04.2022	Keşif Yaklaşımları ve Uygulamaları
10	4.05.2022	Tatil - Ramazan Bayramı Arifesi
11	11.05.2022	Robot Üzerinden Görüntü İşleme Teknikleri
12	18.05.2022	Uygulama 1-2 (Laboratuvar)
13	25.05.2022	3B Haritalama Yöntemleri
14	1.06.2022	Proje Sunumları

Structure from stereo

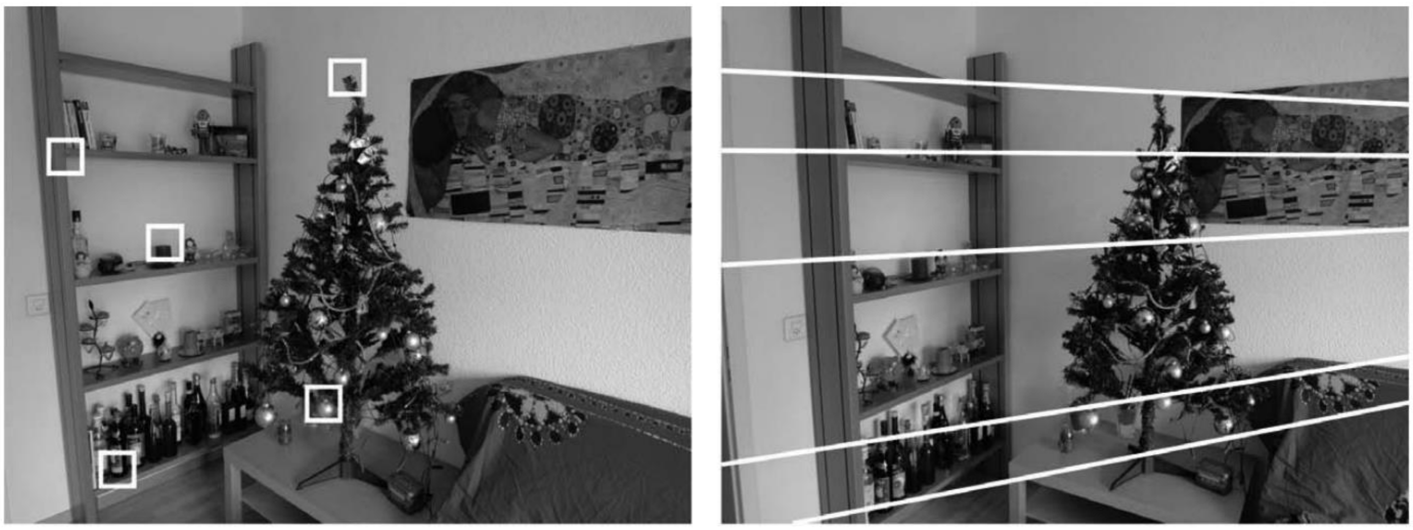
- Recover the structure (depth of points) of the environment from two images taken by two distinct cameras, whose relative position and orientation is known
- Two major problems
  - Correspondence problem
  - 3D reconstruction
- Correspondence : which point in first image matches with which point in second image
- 3D construction : calculate depth from matching points

Structure from stereo – Horizantally perfectly aligned cameras - Matching

```
For each epipolar line
    For each pixel in the left image
        compare with every pixel on same epipolar line in right image
        pick pixel with minimum match cost
```

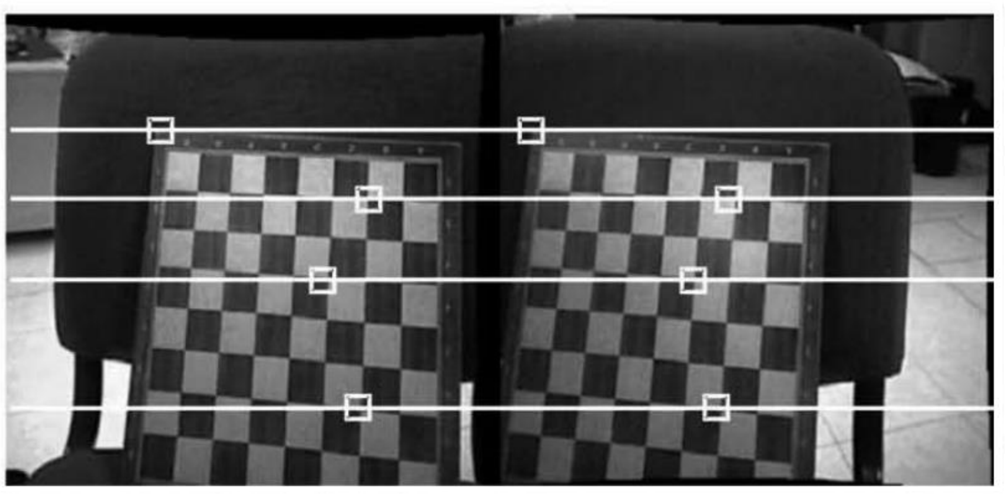


Structure from stereo – General case - Epipolar geometry



Structure from stereo – General case - Epipolar rectification

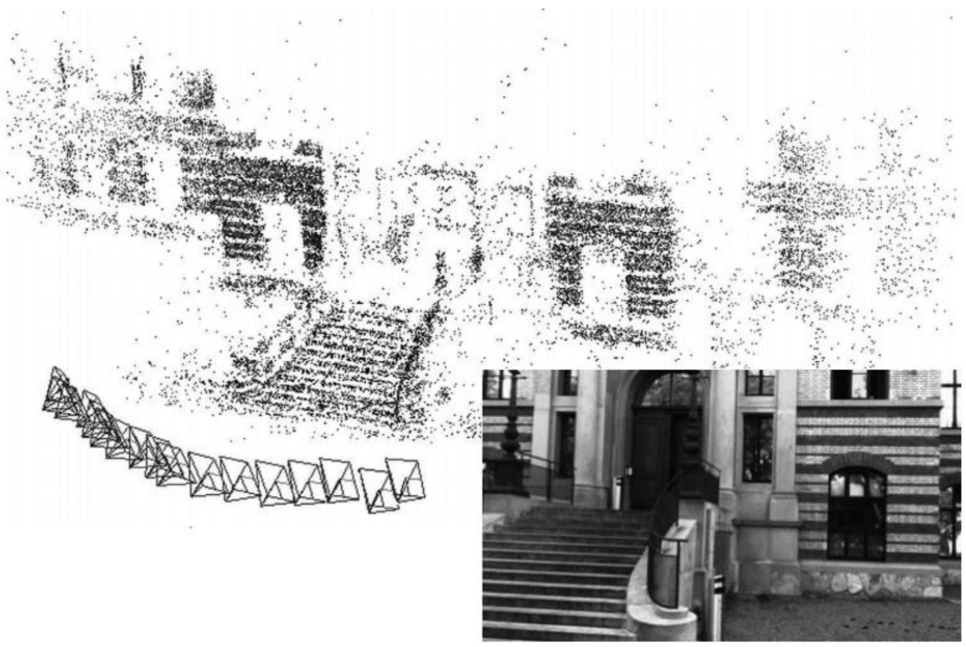
Original
Lens distortion
T&R
Horizantal match



Structure from motion

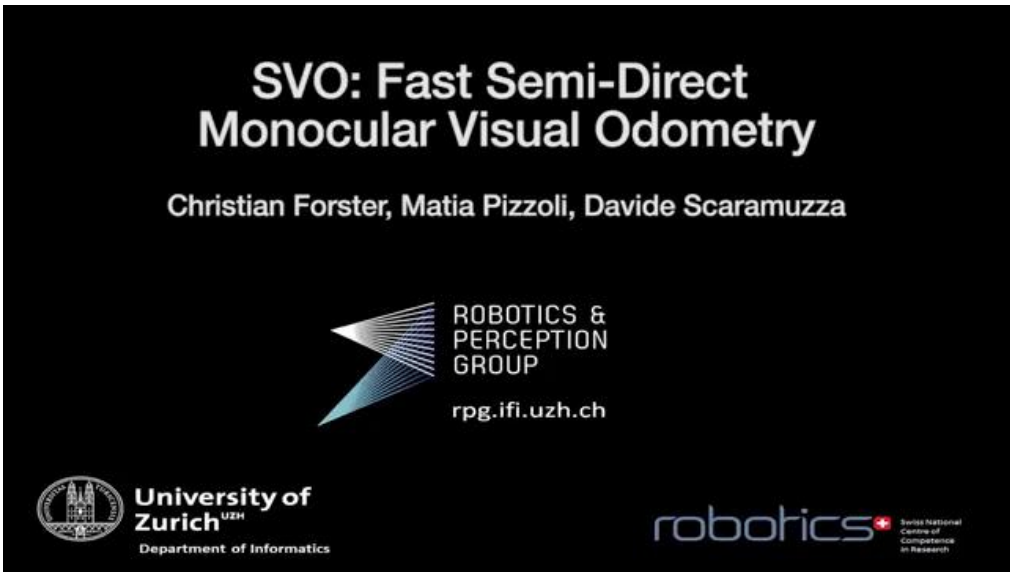
- Process two images taken with the same camera at different times and from different unknown positions
- Both motion and the structure should be estimated

Structure from motion



Structure from motion - Visual odometry

https://www.youtube.com/watch?v=2YnIMfw6bJY


SVO: Fast Semi-Direct Monocular Visual Odometry

Christian Forster, Matia Pizzoli, Davide Scaramuzza

ROBOTICS & PERCEPTION GROUP

rpg.ifi.uzh.ch

University of Zurich UZH

Department of Informatics

robotics Swiss National Centre of Competence in Research

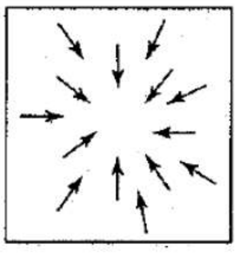
Motion field and Optical flow

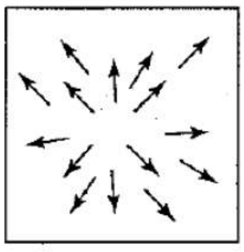
- Motion field : If a point in the environment moves with velocity vo, this correspondes to a motion with velocity vi in image plane
- Optical flow : If light source moves the brightness pattern in image moves too

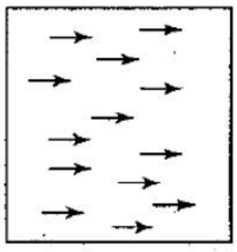
- Motion field : real World 3d motion
- Optical flow : Projection of the motion field onto the 2D image

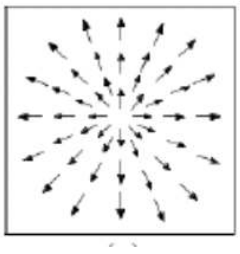
- Estimate motion by optical flow

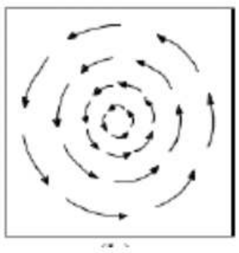
Motion Field

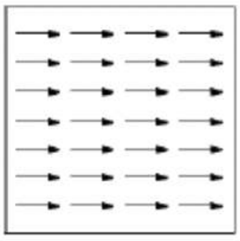

Zoom out

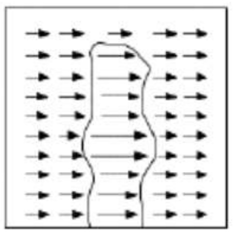

Zoom in


Pan right to left


Forward motion


Rotation


Horizontal translation


Closer objects appear to move faster!!

Color Tracking

- Color thresholding

$$R_{min} < r < R_{max} \ \ and \ \ G_{min} < g < G_{max} \ \ and \ \ B_{min} < b < B_{max}$$

- Color Segmentation
  - Adaptive thresholding
  - K-means clustering

  → Floor plane extraction

Image Filtering

- Frequency domain filtering
- Spatial Filtering

$$I'(x,y) = \sum^{a} \sum^{b} w(s,t)\,.\,I(x-s,y-t)$$

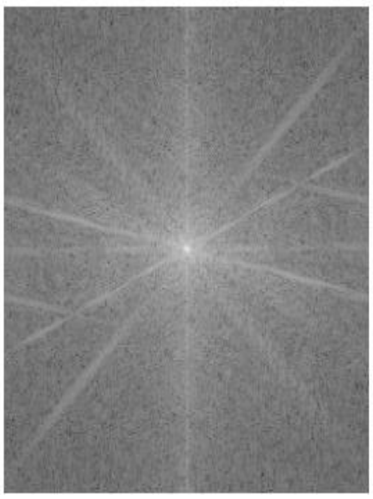
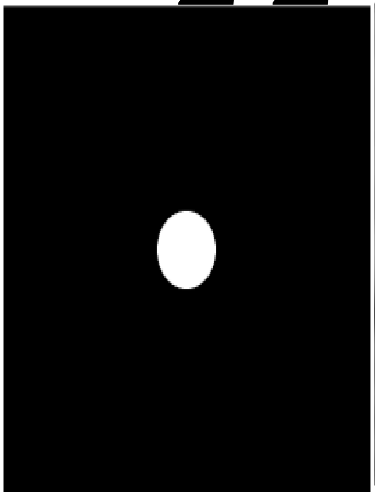
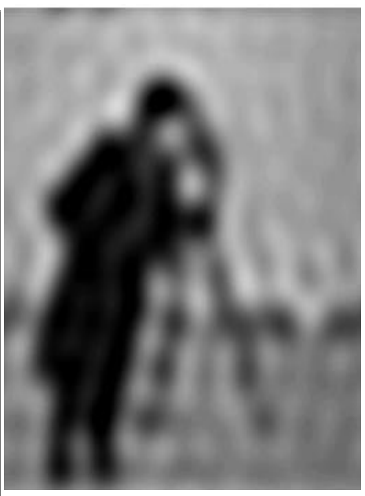




Image Filtering – Spatial Filtering - Smoothing Filters

- Median Filter : Non-linear filter

- Mean Filter : $w = \frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

- Gauss Filter : $G_\sigma(x, y) = \eta e^{-\frac{x^2+y^2}{2\sigma^2}}$ → $w = \frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$

Image Filtering – Spatial Filtering – Edge Detection

- Roberts Filter : $r_1 = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}, r_2 = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}, |G| = \sqrt{r_1^2 + r_2^2}$
- Prewitt Filter : $p_1 = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}, p_2 = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix},$
  $|G| = \sqrt{p_1^2 + p_2^2}, \theta = \operatorname{atan}\left(\frac{p_1}{p_2}\right)$
- Sobel Filter : $s_1 = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}, s_2 = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix},$
  $|G| = \sqrt{s_1^2 + s_2^2}, \theta = \operatorname{atan}\left(\frac{s_1}{s_2}\right)$

Straight Edge Extraction – Hough Transform

- A line is defined as $y = mx + b$
- Initialize a 2D matrix A with axes carry possible values of m and b
- For every edge pixel (xp,yp) loop over all m and b vaules
- If yp=m.xp+b then A[m,b]++
- Largest value of A at m and b means a straight line with parameters m and b

Feature Extraction

- Two strategies for sersor input evaluation
- Raw, individual sensor data → low level features
- Extract information from one or more sensor readings → high level features

Feature Extraction

- Decision on appropriate features
- Target environment : Office environment → line features, Mars Rover → visual odometry
- Available sensors : laser range finder → line features, sonar sensor → single point ranging
- Computational power : visual features → costly
- Environment representation : continuous rep. → line features, occupancy grid rep. → ranging

Properties of ideal feature detectors

- Repeatability
- Distinctiveness
- Localization accuracy
- Quantity of features
- Invariance
- Computational efficiency
- Robustness

Corner Detectors

- Corner : intersection of one or more edges
- Corners are with high repeatability
- Moravec corner detection : patch similarity calculation with SSD (sum of squared differences) $\rightarrow$ locally maximal SSD value shows a corner
- Harris corner detection : first order Taylor expansion for image around pixel (u,v) with changing x and y

$$I(u+x, v+y) \cong I(u,v) + I_x(u,v)x + I_y(u,v)y$$

Harris Corner Detector

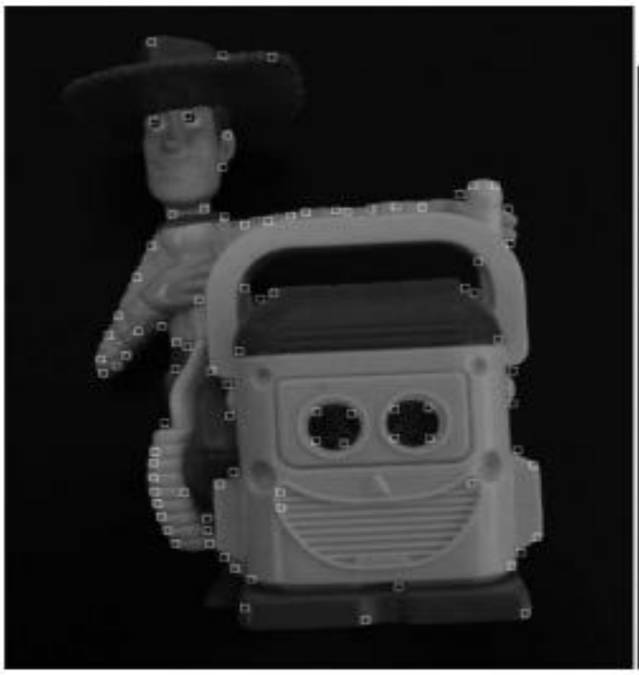
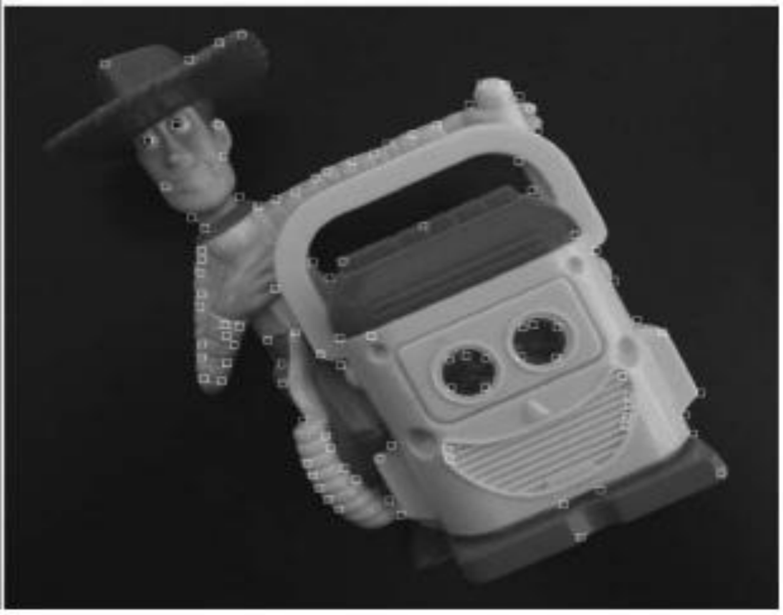
$$SSD(x,y) \cong \sum_u \sum_v \left[I_x(u,v)x + I_y(u,v)y\,\right]^2$$

$$= [x \quad y] \sum_u \sum_v \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$= [x \quad y] R^{-1} \begin{bmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{bmatrix} R \begin{bmatrix} x \\ y \end{bmatrix}$$

R: orientation, λ: change rate

Harris Corner Detector

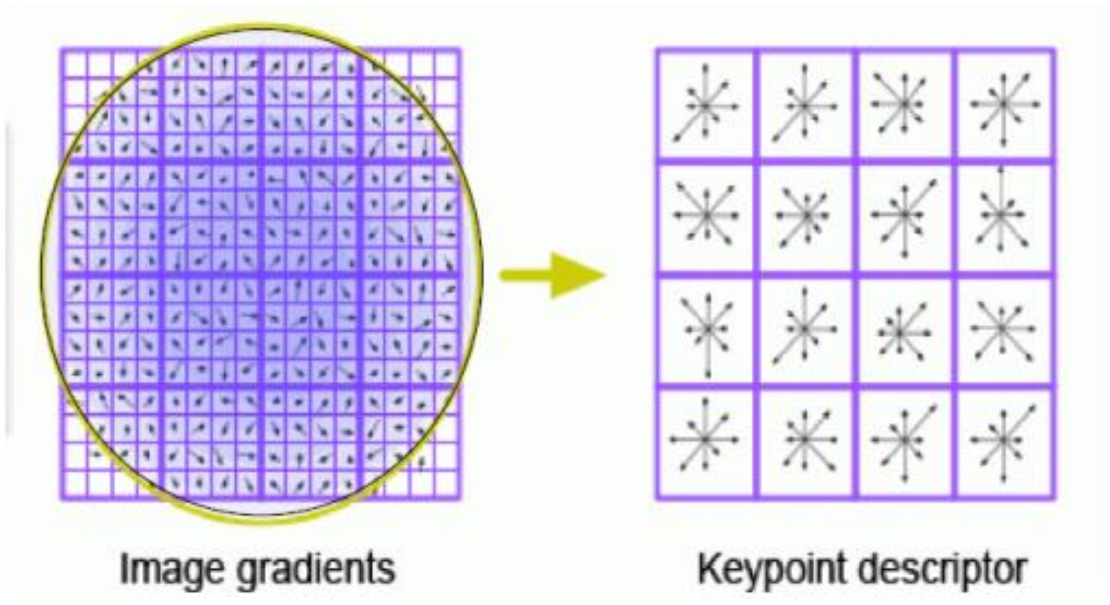



Blob Detectors

- Blob: an image pattern that differs from its immediate neighborhood in terms of intensty, color and texture
- Location accuracy is smaller than a corner
- Scale and shape accuracy is better defined compared to a corner

SIFT Features

Gaussian blurred images at different scales.
Difference of Gaussian images.
Keypoint selection as local maxima or minima of the DoG images
Orientation assignment
Keypoint descriptor



sensor_msgs/LaserScan

```
# Single scan from a planar laser range-finder
#
# If you have another ranging device with different behavior (e.g. a sonar
# array), please find or create a different message, since applications
# will make fairly laser-specific assumptions about this data

Header header           # timestamp in the header is the acquisition time of
                        # the first ray in the scan.
                        #
                        # in frame frame_id, angles are measured around
                        # the positive Z axis (counterclockwise, if Z is up)
                        # with zero angle being forward along the x axis

float32 angle_min        # start angle of the scan [rad]
float32 angle_max        # end angle of the scan [rad]
float32 angle_increment  # angular distance between measurements [rad]

float32 time_increment   # time between measurements [seconds] - if your scanner
                         # is moving, this will be used in interpolating position
                         # of 3d points
float32 scan_time        # time between scans [seconds]

float32 range_min        # minimum range value [m]
float32 range_max        # maximum range value [m]

float32[] ranges         # range data [m] (Note: values < range_min or > range_max should be discarded)
float32[] intensities    # intensity data [device-specific units]. If your
                         # device does not provide intensities, please leave
                         # the array empty.
```

sensor_msgs/Image   RGB or Depth

```
# This message contains an uncompressed image
# (0, 0) is at top-left corner of image
#

Header header        # Header timestamp should be acquisition time of image
                     # Header frame_id should be optical frame of camera
                     # origin of frame should be optical center of cameara
                     # +x should point to the right in the image
                     # +y should point down in the image
                     # +z should point into to plane of the image
                     # If the frame_id here and the frame_id of the CameraInfo
                     # message associated with the image conflict
                     # the behavior is undefined

uint32 height         # image height, that is, number of rows
uint32 width          # image width, that is, number of columns

# The legal values for encoding are in file src/image_encodings.cpp
# If you want to standardize a new string format, join
# ros-users@lists.sourceforge.net and send an email proposing a new encoding.

string encoding       # Encoding of pixels -- channel meaning, ordering, size
                      # taken from the list of strings in include/sensor_msgs/image_encodings.h

uint8 is_bigendian    # is this data bigendian?
uint32 step           # Full row length in bytes
uint8[] data          # actual matrix data, size is (step * rows)
```

sensor_msgs/PointCloud

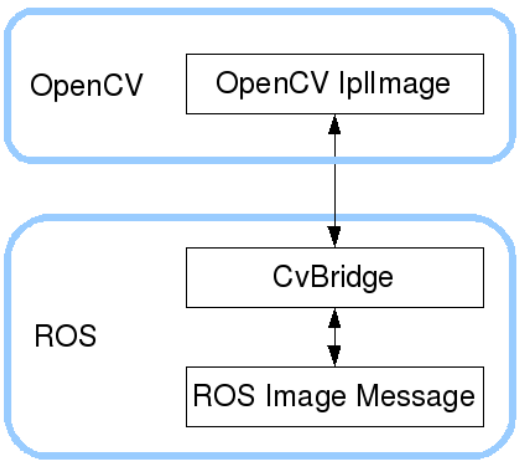
```
# This message holds a collection of 3d points, plus optional additional
# information about each point.

# Time of sensor data acquisition, coordinate frame ID.
Header header

# Array of 3d points. Each Point32 should be interpreted as a 3d point
# in the frame given in the header.
geometry_msgs/Point32[] points

# Each channel should have the same number of elements as points array,
# and the data in each channel should correspond 1:1 with each point.
# Channel names in common practice are listed in ChannelFloat32.msg.
ChannelFloat32[] channels
```

cv_bridge



Sabırla Dinlediğiniz İçin Teşekkürler