# Exercise: Stable Interest Point Detection Using a Visual Buffer

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## 1 Introduction

SIFT interest points are used in visual Simultateous Localization and Mapping to represent the environment of the robot. SIFT results in a high number of interest points. This is very good for object and scene recognition, but gives problems for SLAM methods, since all the interest points and their position need to be stored and estimated. This is too much information to process in real-time. SIFT furthermore results in many interest points that are unstable, which means that they cannot be tracked over a number of subsequent images. To create high quality maps of the environment, it is important to store stable landmarks, which can be detected robustly from a number of nearby locations.

The goal of this exercise is to implement a visual buffer that tracks the interest points over a number of subsequent images and detects stable interest points. We call an interest point stable when we can robustly detect it in a sequence of images and when we can reliable detect the position of the interest point in world coordinates. The later constraint filters out points that are wrongly matched, or that cannot be accurately localized in the image. This is similar to the matching buffer proposed in [Frintrop et al., 2006].

Excercise:

- Read [Frintrop et al., 2006] and focus on the filtering of stable landmarks
- Implement the visual buffer to track the interest points and design a measure of the stability of the interest points.
- Implement the triangulation to estimate the position of the interest points in world coordinates based on two observations.
- Design a measure of stability that favors interest points that can be accurately estimated within the buffer.
- Test the effect of the method by storing stable interest points on the sequence `min_cloudy1` and matching them with (stable) interest points in the sequence `min_cloudy2`, which is taken in the same environment, but at a different time.

- If time is available, think of other methods to measure the stability of interest points, perhaps by testing how noise robust the interest points are.
- Prepare a 10 min. presentation with an introduction to the problem, the used method, the experiments and results, and a discussion about the method and possible future directions.

# 2 Some background

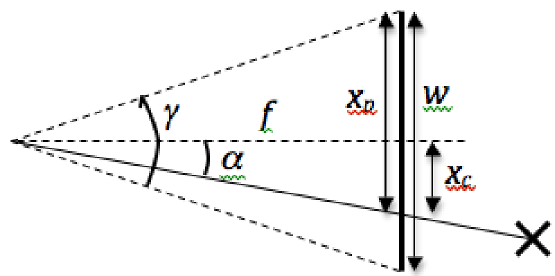


Figure 1: Camera layout.

## 2.1 From image position to angle

In this exercise we are only interested in the 2D world position of the interest points. We will not look at the height of the point. We therefore only need to consider the horizontal angle towards the interest point. Figure 1 gives an overview. The interest point is observed in the image at the pixel with x-coordinate $x_p$. $x_c = x_p - \frac{w}{2}$ is the distance in pixels from the center of the image. The angle towards the interest point is calculated by:

$$\alpha = \arctan(\frac{x_c}{f}) \tag{1}$$

$$f = \frac{\frac{1}{2}w}{\tan\frac{1}{2}\gamma} \tag{2}$$

where the width of the image $w = 320$, and the horizontal field of view of the camera is $\gamma = 45^o = 0.79\text{rad}$.

NB. Pay attention that an observation of an interest point at the left side of the imae will now result in a negative angle. Look carefully if this fits the orientation of angles in the robot odometry coordinates.

### 2.2 Triangulation

The position of an interest point in the environment can be calculated using triangulation on the basis of two observations of the interest point at different positions in the environment. For the triangulation, the distance between the robot's position at the first and second observation need to be known, as well as the angles towards the interest point at both positions. We have information about the position from the robot's odometry. The angles can be inferred from the orientation of the robot and the x-position of the observation in the camera image.

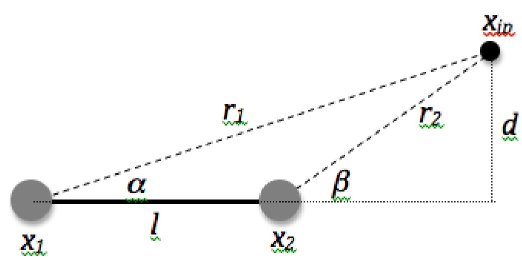


Figure 2: Triangulation.

The situation of observing an interest point in two subsequent images in displayed in Figure 2. From the position of the interest point in image, we know the bearings $\alpha$ and $\beta$. From the odometry of the robot, we know the distance $l$ between the robot position $x_1$ and $x_2$. Using basic geometry the position of the landmark $x_{ip}$ can be established.

NB. The estimation of the position of the landmark will be most accurate with sufficient parallax, that is when $\alpha$ and $\beta$ are sufficiently different.

Read more about triangulation: http://en.wikipedia.org/wiki/Triangulation .

### 2.3 Odometry

With `getIDOLSequenceInfo` information about the robot run can be retrieved. The fields x, y, and a give the xy position and orientation of the robot.

## References


[Frintrop et al., 2006] Frintrop, S., Jensfelt, P., and Christensen, H. I. (2006). Attentional landmark selection for visual slam. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS '06).*