Optical Flow and Local Depth Map through indoor corridors in the case of linear motion. If the translational speed is moving with a translational speed. Using two one-dimensional sensors pointing at ±90° have been developed in [3], [5]. A single-camera frontal collision-avoidance strategy computing the divergence of the OF is proposed in [6]. The OF has also been used for implementing altitude control as in [7], [8].

In some approaches the average intensity of the left and right OF vectors is balanced, according to the fact that if the left optical flow is larger than the right one, it means that the object is closer to the flanking walls.

Other on-board sensors like cameras, radar, lasers, sonars and IMUs (Inertial Measurement Units). A stereo camera can be employed as in [9], [10].

Introduction

Optical Flow: image feature motion between two consecutive camera frames. It is usually expressed in units of angular velocity, i.e. radians per second or degrees per second.

Dynamic Region of Interest

Navigation (OF) feature extraction process:

- Large benefit in terms of computational requirement.
- Systems becomes “blind” outside the RoI.
- Online selection adapting to the environment and navigation conditions to reduce the risk of impact.

Fusion of Vision and IMU to compute distances towards detected objects based on the relative velocity respect to the object and on the angle between the direction of motion and the observed feature with the following rule:

\[ d = \frac{H}{2} \sin(\alpha) \]

where \( d \) is the distance between the object feature and the camera.

- IMU is used to compensate the rotational part using configuration angles of the vehicle.

- Fusion of vision and IMU data to compute the scale factor needed to estimate an absolute local depth map (ADM)

Reactive Obstacle Avoidance

On-line local modification of the planned trajectory performed by the Reactive Motion Planner:

- Correction obtained with respect to a safety lateral distance from the detected obstacles in the left and right RoI using PD controller.

Time to Contact

The velocity is reduced approaching an obstacles considering the application of a virtual repulsive force field in the desired direction of motion generating on the basis of the ADM the Relative Depth Map (RDM) is employed for the navigation through indoor corridors in the case of linear motion.

Fusion of Vision and IMU for Scale Factor

Starting from the solution proposed in [14], a new compact formulation is adopted for the ADM estimation, providing a generalization to the case of multiple visual station and image features:

- It is assumed that the period of the visual system is \( N \) times the period of the IMU system \( T \). So between two consecutive images there are \( N \) available measures provided by the IMU.

- BU and the camera reference frames are coincident.

- \( n_x \geq 2 \) visual stations and \( N \) image features.

- System of \( 2n_x \) equations with \( 3n_x \) unknowns \( n_x \) and \( d \), where \( d \) is the 2D vector of distances of each image feature.

- Linear system obtained that for \( n_x = 2 \) and \( n_x = 1 \) becomes a square system of 4 equations in 4 unknowns. In a general case:

\[ \begin{align*}
    d_1 &= f s_x (R_1 \hat{e}_d) [d_1 f_s (R_1 \hat{e}_d)] \\
    d_2 &= f s_x (R_2 \hat{e}_d) [d_2 f_s (R_2 \hat{e}_d)] \\
    X_A &= A [v_t]
\end{align*} \]

- If \( n_x \) is increased, the number of unknowns do not change, the complexity of the system solution remains the same, and the baseline employed for the triangulation considered in the equation system is enlarged.

- Increasing \( n_x \) the same number of IMU data is employed but the number of unknowns increases linearly: the matrix \( A \) assumes a sparse configuration and the system solution becomes quickly inefficient.

- \( n_x = 2 \) and \( n_x = 3 \) is a good solution if a good IMU system is available.

References