real-time systems. In this section, we describe the image processing methods used for different stages and the respective simplifications in terms of the real application.

As mentioned above, we propose to use disparity information directly for tracking and visual navigation of the mobile robot. Since indoor environments contain many vertical contours, and the obstacles to be avoided by a mobile robot are often standing on the ground, we use vertical edges to represent them. The idea is that after capturing a stereo image pair, we perform vertical edge detection then stereo matching to find the vertical edges in space. We need to distinguish which vertical edges represent an object standing on the ground and which are lying on the ground, so are not an obstacle. This is done by using the ground plane disparity map constructed a priori.

2.1 Edge detector

A Sobel vertical edge detector is used to do edge detection, which reduces the time for the horizontal edge detection. Two thresholds of edge contrast value are adopted. The detected vertical edges whose contrast values exceed a low threshold are connected in different edge strings according to their position and direction. Hysteresis is applied to delete those strings whose lengths are below a length threshold and those strings none of whose contrast values exceed the high contrast threshold. The remaining strings are used for stereo matching. This greatly reduces the computational expense of stereo matching.

2.2 Stereo matching

The PMF[11][10] stereo matching algorithm is used because of its reliability and speed, especially for vertical edges. To simplify matching, a parallel camera geometry has so far been adopted. Since we use edge strings for matching, only selected seed edge points from strings are used to compute matches and then matching is relaxed to the whole string. This technique greatly reduces the computational expense. Matching is performed from the left image to the right and from the right image to the left in parallel. If two edge points choose each other as their matching point, these two points form a match pair;

2.3 Obstacle detection

The easiest way to detect an obstacle standing on the ground is to use a dense prediction of ground plane disparity to distinguish whether the point is on the ground or over the ground. In this section, we first investigate whether the ground disparity can be represented as a plane in the image coordinates x and y. Then, we use the ground images with special line features on the ground and without obstacles to train the system and get the parameters of the predicted ground disparity plane. This can then be used to detect obstacles standing on the ground.

1. Ground disparity plane

From Figure 2, when the head elevation angle $\theta$ has a certain constant value, the ground disparity plane obeys:

$$\delta(y) = \frac{f * d}{h} * (\cos(\theta) - \frac{y}{f} * \sin(\theta)) \quad (1)$$

$$= \frac{f * d}{h} * \cos(\theta) - \frac{y * d}{h} * \sin(\theta) \quad (2)$$

$$= K_1 + K_2 * y \quad (3)$$

Here $\delta(y)$ is the ground disparity as a function of y; y is the image coordinate; f, d, h are vision geometry parameters: d represents the distance between the two camera optic centres, and f is the camera focal length.

2. Parameter Fitting

The problem is: given a set of observation data x, y (image coordinates) and z (here representing disparity), to fit parameters a, b, c to obey the equation:

$$z = a * x + b * y + c \quad (4)$$