EXTRACTION AND ELIMINATION OF PARALLEL OBSTACLES FOR IMAGE RESTORATION

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Background

- Scenes are often occluded by various obstacles: branches, trees, fences

- Mobile robot inside fences: must recognize a scene behind the obstacles
Objective

Extracting fences in an image
Restoring the background
Overview of the Method

Parallel case

Edge detection

Hough transform

Autocorrelation with Fourier transform

Estimate interval in Hough space

Find lines in the image

Mask fence regions

Restore the background

Non-Parallel case

Estimate vanishing points and line by LMedS

Estimate interval on vanishing line

Find lines in the image through Hough space
**Fence: Parallel to the Camera**

**Assumptions:**
- Parallel lines make the fence in a space.
- The projection of the lines are still **parallel** in an image.

The optical axis of the camera is perpendicular to the fence. (fence and the image plane are parallel)
Angles and Interval of Fence Lines

Identifying parallel and periodic lines on a fence by using autocorrelation

Fourier spectrum $\mathcal{F}\{I\}$ of the image $I$

Autocorrelation

$$I_a = \mathcal{F}^{-1}\{|\mathcal{F}\{I\}|^2\}$$

original image
Detecting Lines by Hough Transform

Count edge pixels on the lines with angle $\theta_1$ at the distance $\rho$ from the origin.

Prominent peaks with the equal interval $f_1$
Localizing Lines on the Fence

Hough space

Localized lines on the fence

Number of edge pixels on a line with $\theta_1$

$\rho$

Draw lines

Same method for $\theta_2$
**Fence: Not Parallel to the Camera**

**Assumptions:**
- Parallel lines make the fence in a space.
- The projection of the lines are subject to the projective geometry.

The optical axis of the camera is not perpendicular to the fence.
(fence and the image plane are not parallel)
Estimaging Vanishing Points

Original image

Vanishing line

Lines on the fence

vanishing point

Distance $\varepsilon_{ij}$ between an intersection $i$ and a pair $j$ of lines

LMedS method

$(u_i, v_i)$: an intersection of lines

$\varepsilon_{ij}$: distance

Estimated vanishing point

$v = (u_{i*}, v_{i*})$

$i^* = \text{argmin med } \varepsilon_{ij}$
Accumulation on the Translated Vanishing Line

○: The intersections of $\ell'$ and the fence lines

Counting edge pixels on the line $\ell'$

The intersections of $\ell'$ and the fence lines have the equal interval.
Localizing Lines on the Fence

Draw lines

Same method for another set of lines

Hough space

Maximum peak

Number of edge pixels on the line $f_2$
Extraction of Fence Region

Edge image

Expanded lines

AND

Extracted fence region
Disoccluding Fence Region

region to be removed

before

diffusion

after

Impainting equation:

\[ I_t = \nabla(\Delta I)\nabla^\perp I \]

- \( I \): Image
- \( \nabla^\perp I \): edge orientation

(M.Bertalmio, 2000)
Experimental Results

Parallel case
original image (640x480)
Experimental Results

Parallel case
extracted fence lines
Experimental Results

Parallel case
fence removed
Experimental Results

Parallel case
background restored
Experimental Results

Non-Parallel case
original image (640x480)
Experimental Results

Non-Parallel case
extracted fence lines
Experimental Results

Non-Parallel case
fence removed
Experimental Results

Non-Parallel case
background restored
Experimental Results
Future Works

• Improving the approximation of fence rather than straight lines
• Filling the gaps in the extracted fence regions for disocclusion
• Effective tuning for many parameters used
• Automatic image classification: an image is parallel or not parallel to the camera
• Dealing with severely inclined fence