

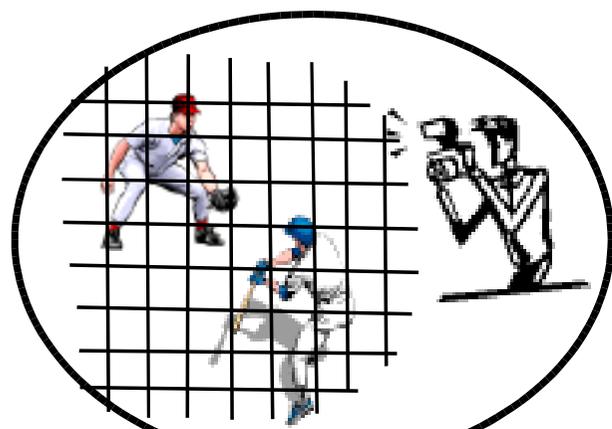
# **EXTRACTION AND ELIMINATION OF PARALLEL OBSTACLES FOR IMAGE RESTORATION**

**Hiroshi Suzuki      Toru Tamaki  
Masanoabu Yamamoto**

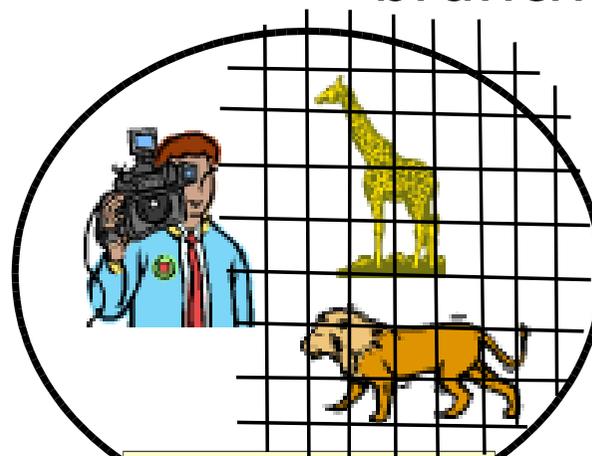
**Niigata University**

# Background

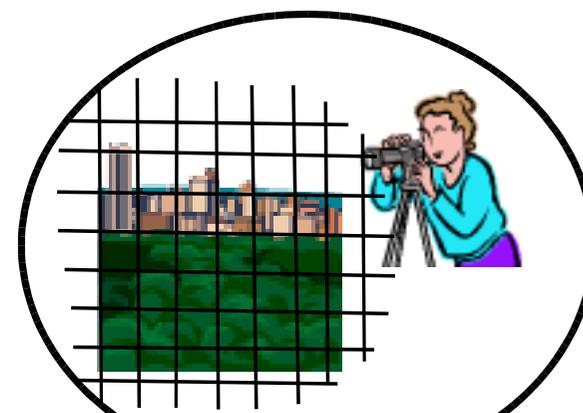
- Scenes are often occluded by various obstacles:  
branches, trees, **fences**



In a ballpark

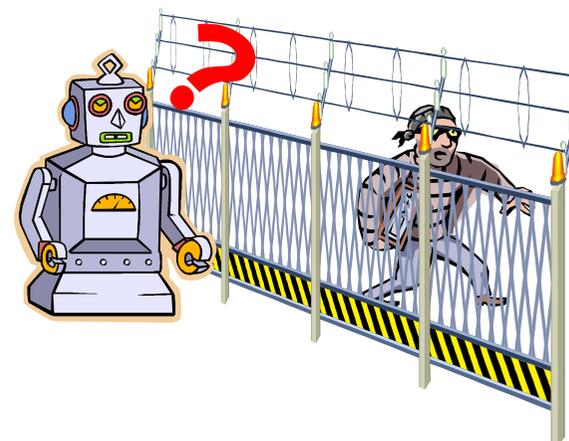


In a zoo



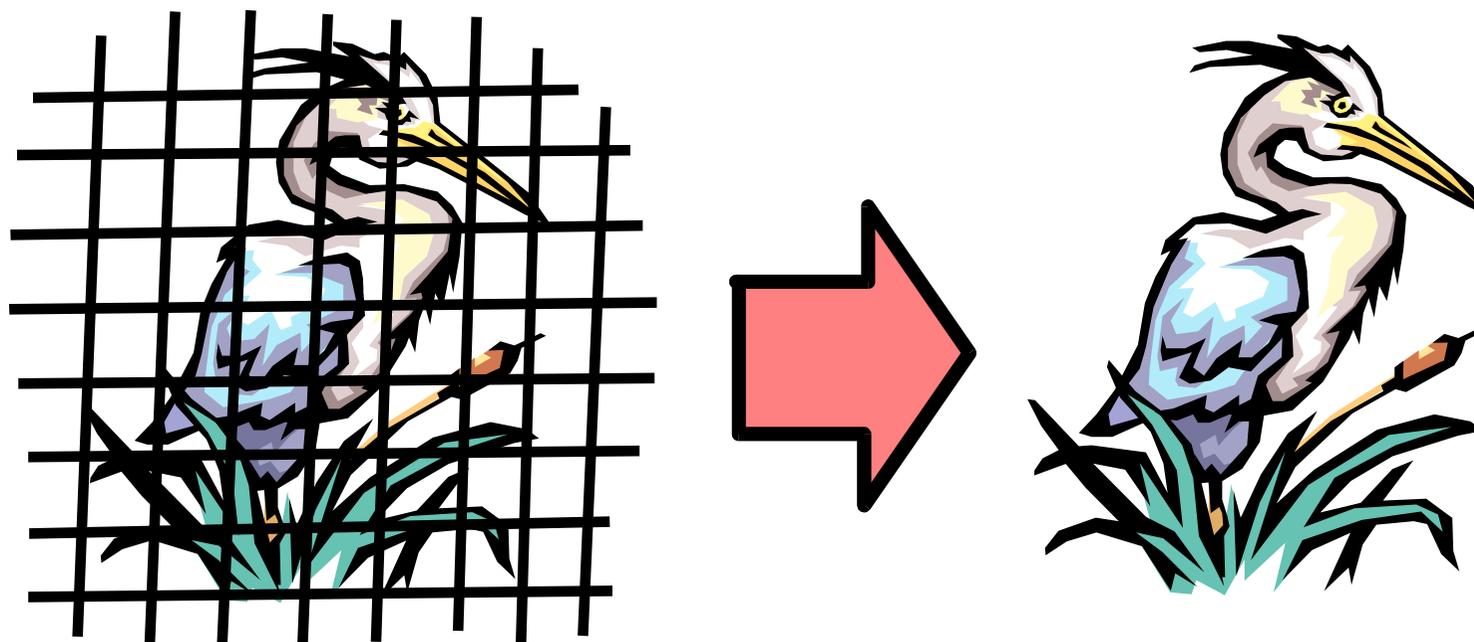
From top of  
a building

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

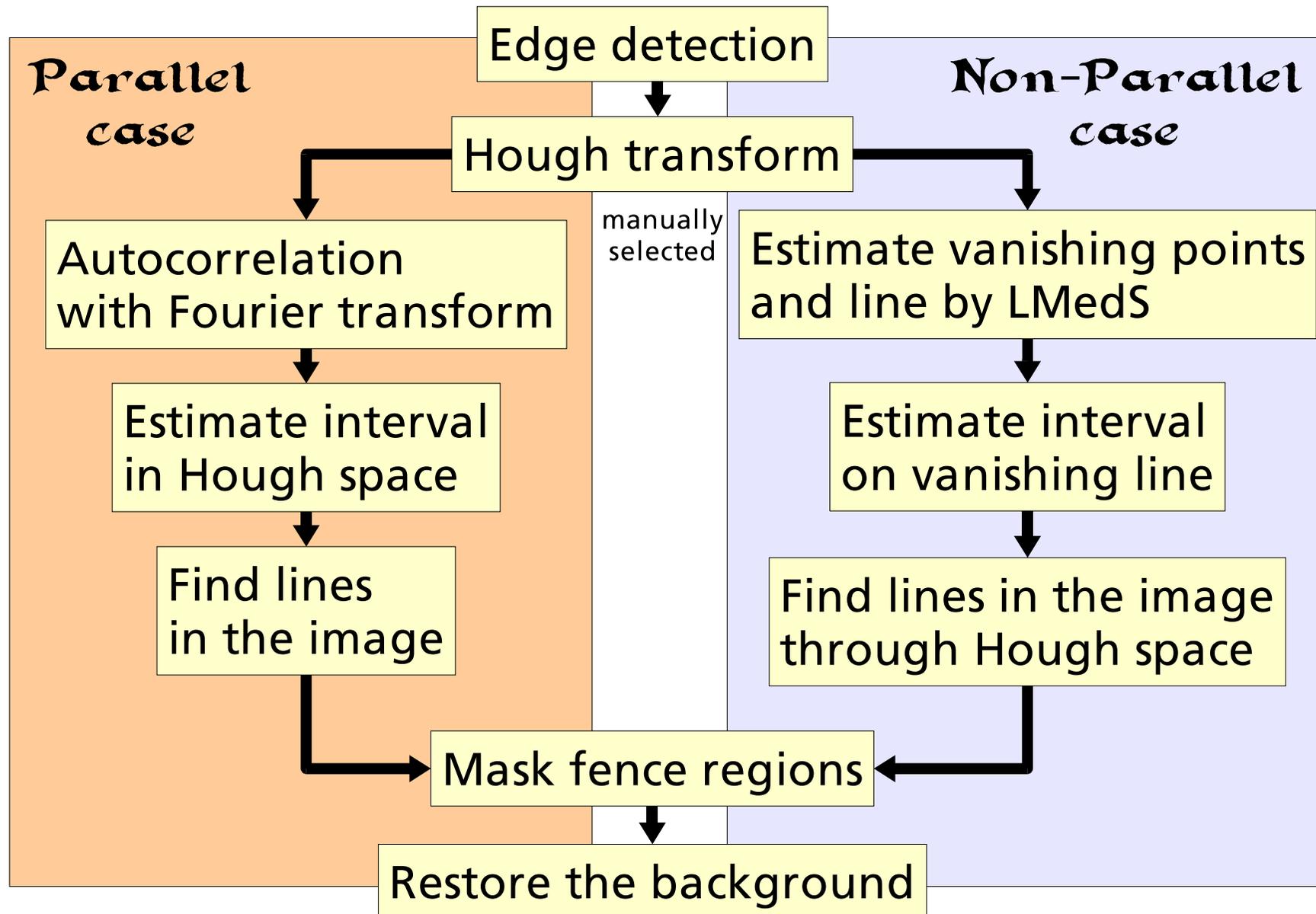


# Objective

**Extracting fences in an image  
Restoring the background**



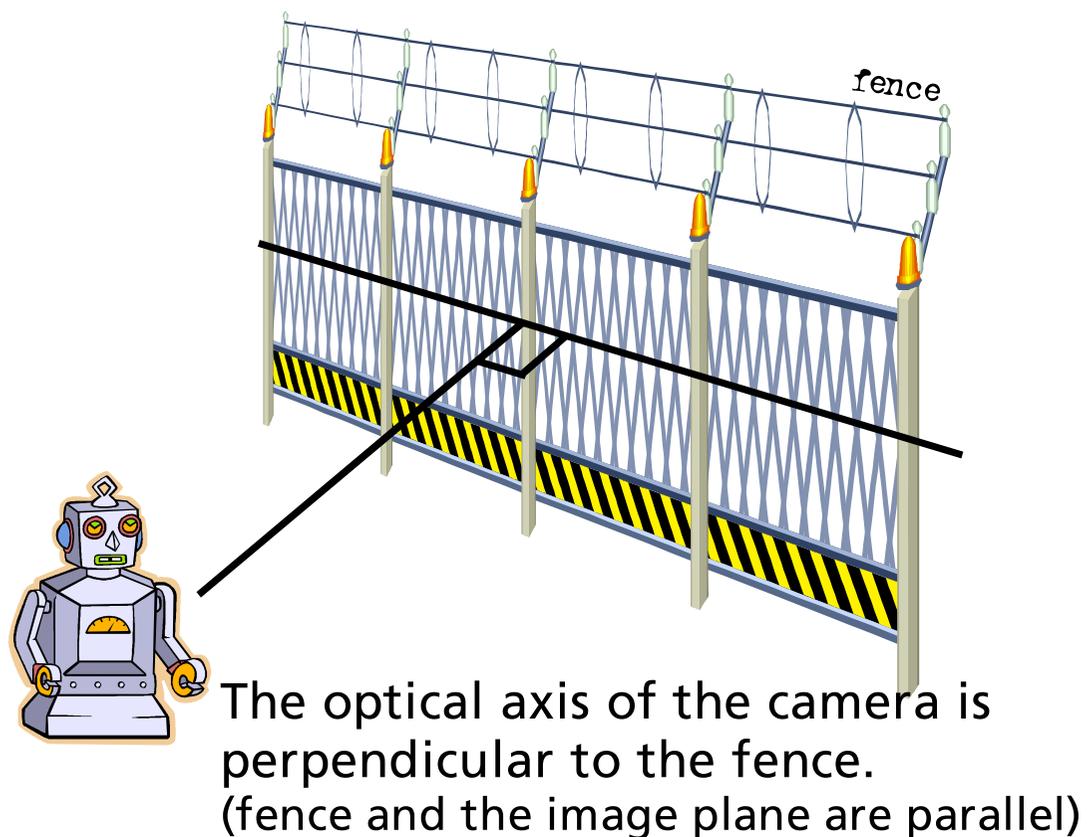
# Overview of the Method



# Fence : Parallel to the Camera

## Assumptions :

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

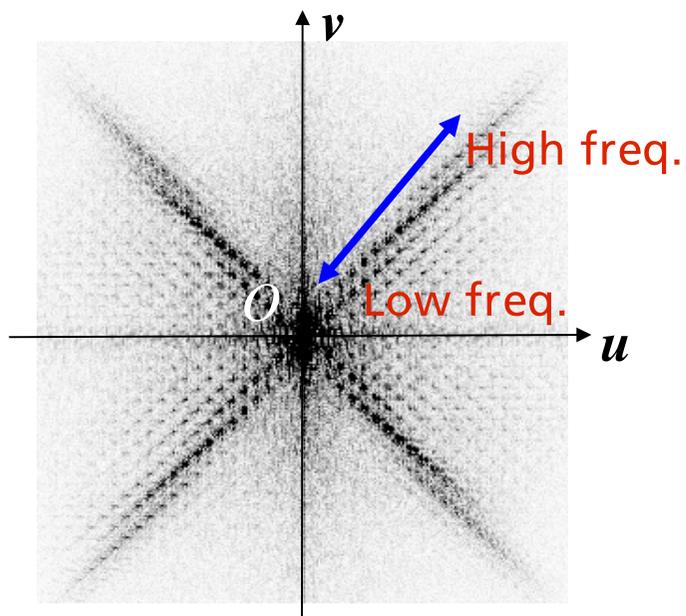


sample view

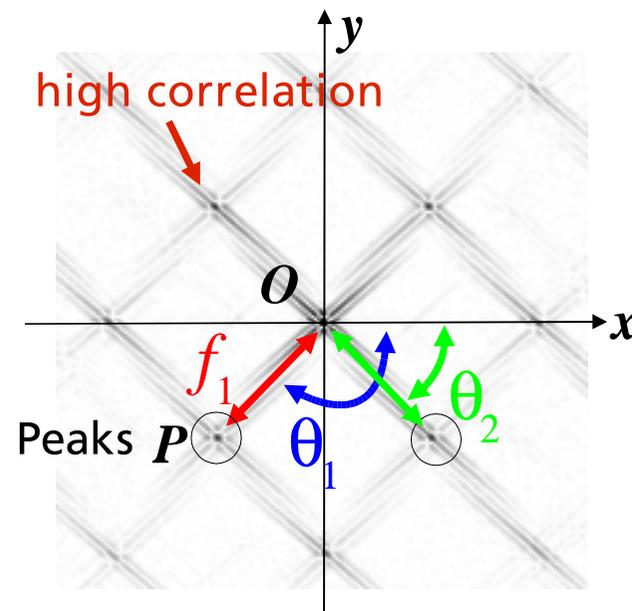


# Angles and Interval of Fence Lines

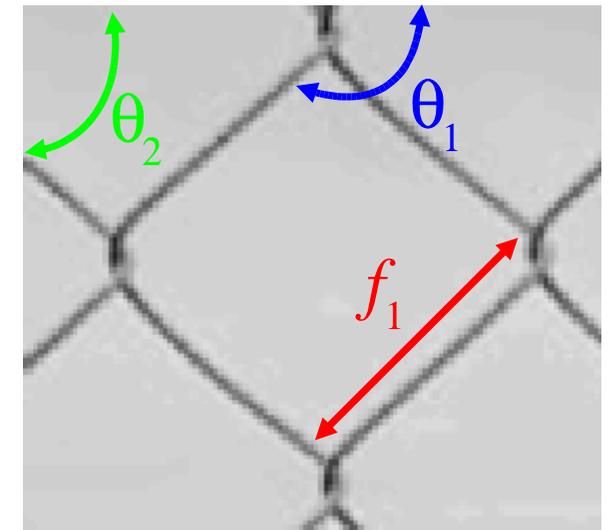
Identifying parallel and periodic lines on a fence by using **autocorrelation**



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

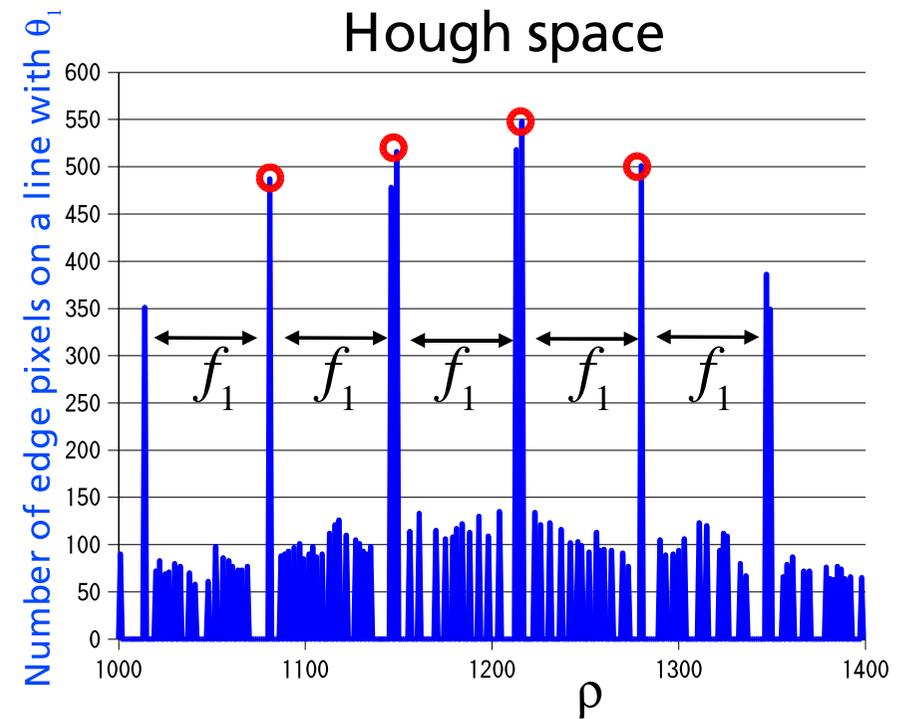
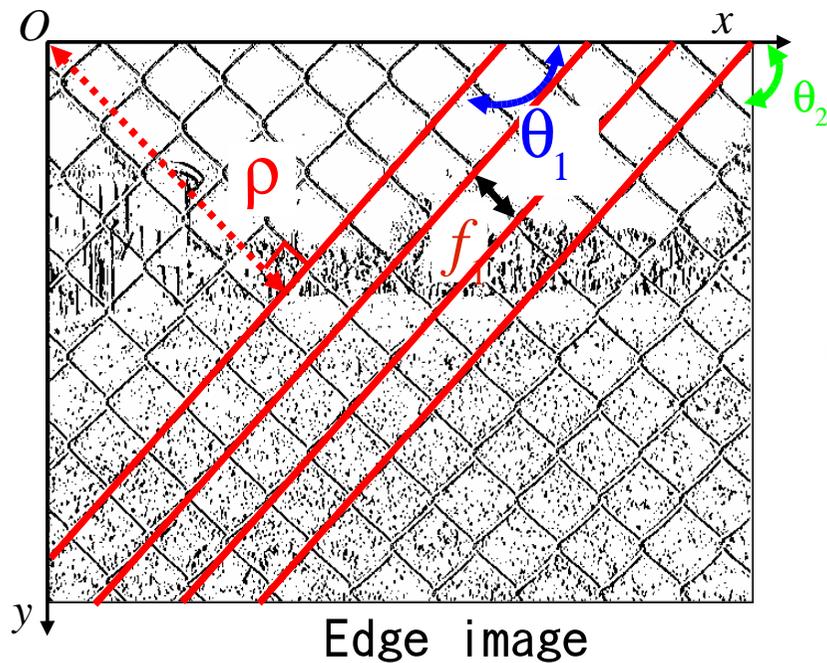


Autocorrelation  
 $I_a = F^{-1}\{|F\{I\}|^2\}$



original image

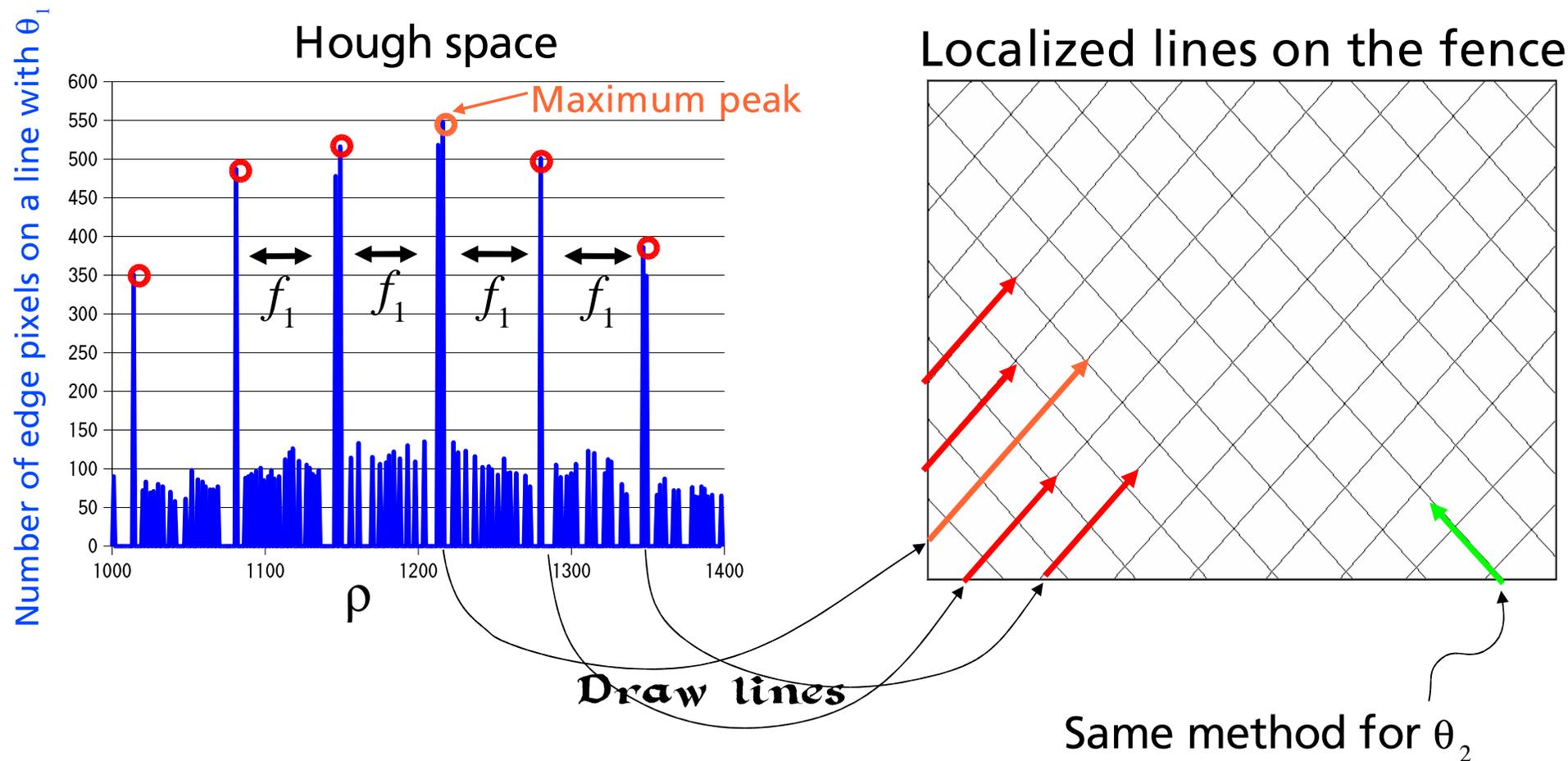
# Detecting Lines by Hough Transform



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

Prominent peaks with the equal interval  $f_1$

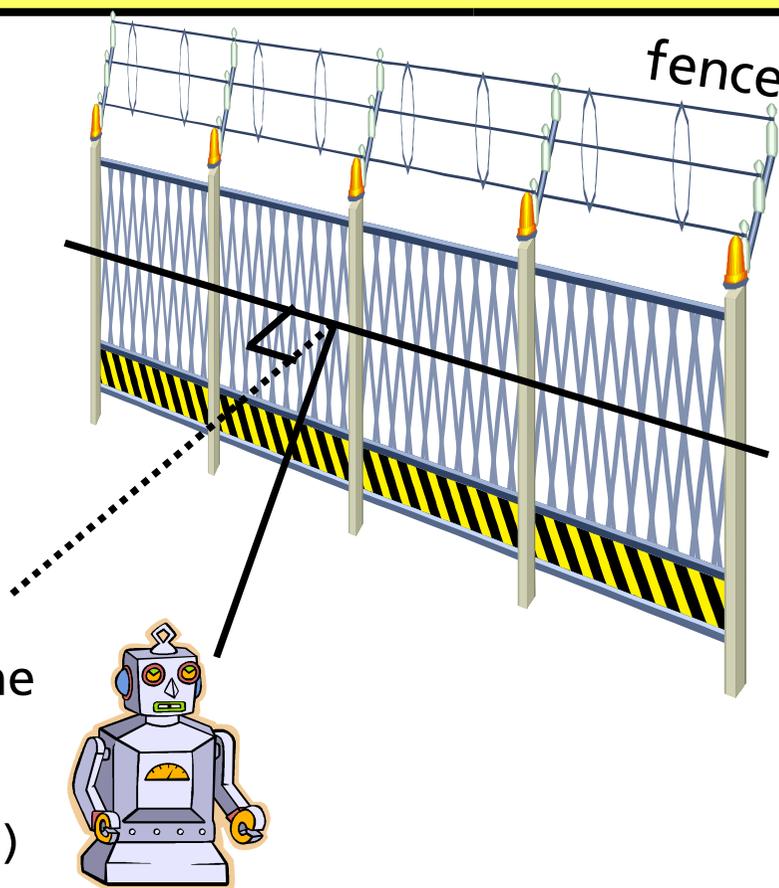
# Localizing Lines on the Fence



# Fence : Not Parallel to the Camera

## Assumptions :

- Parallel lines makes the fence in a space.
- The projection of the lines are subject to the projective geometry.

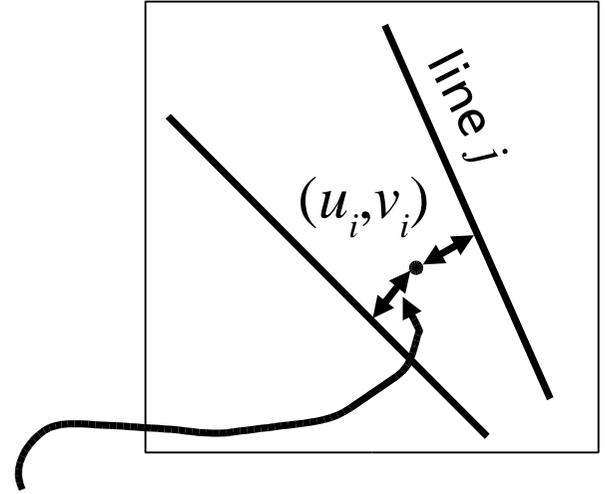
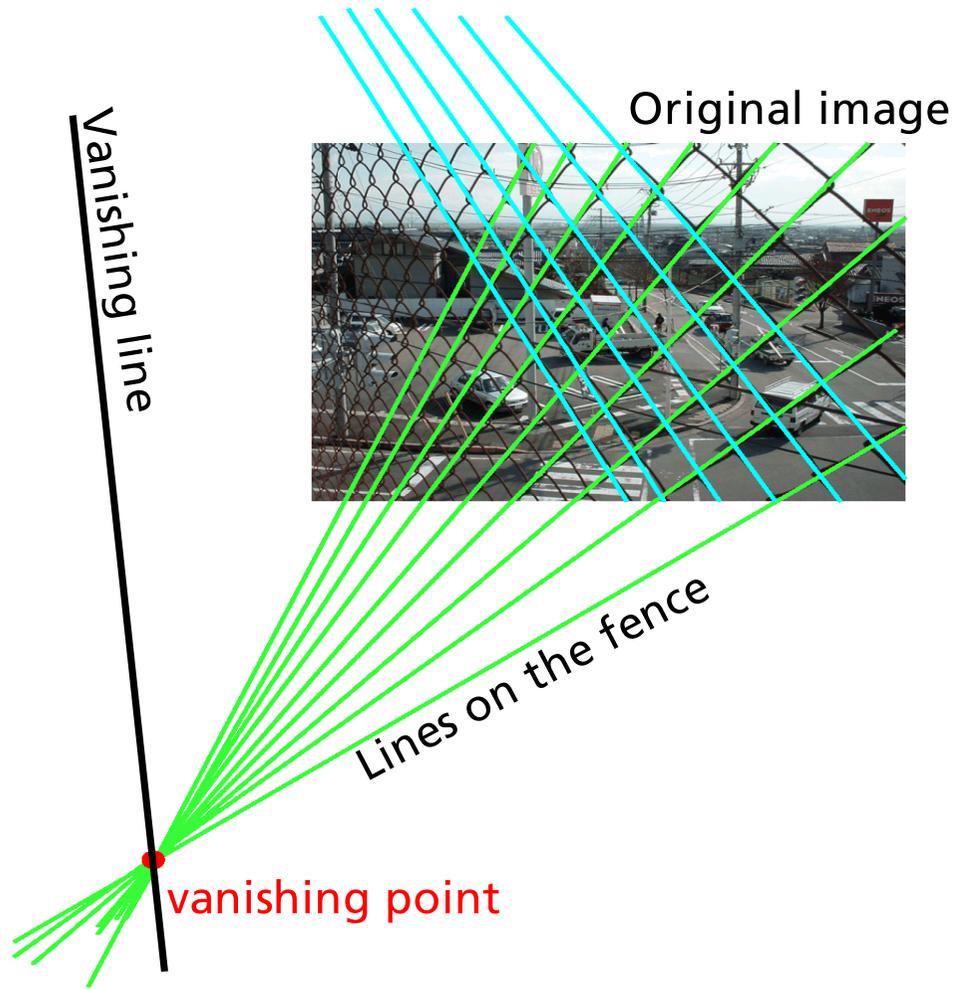


The optical axis of the camera is not perpendicular to the fence.  
(fence and the image plane are not parallel)

sample view



# Estimating Vanishing Points



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

## LMedS method

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

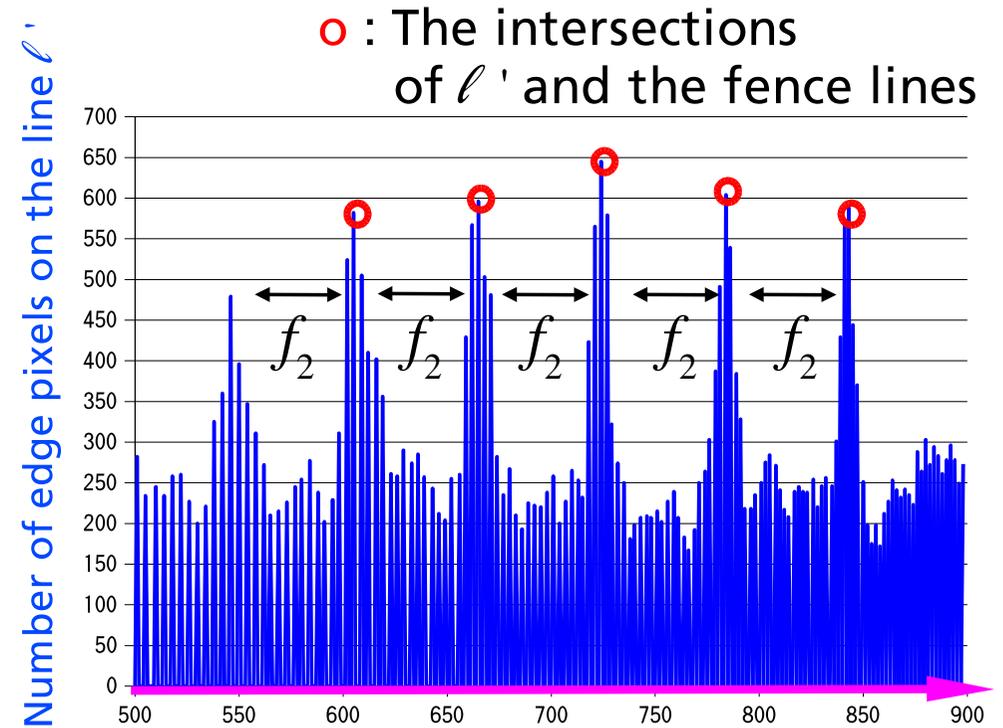
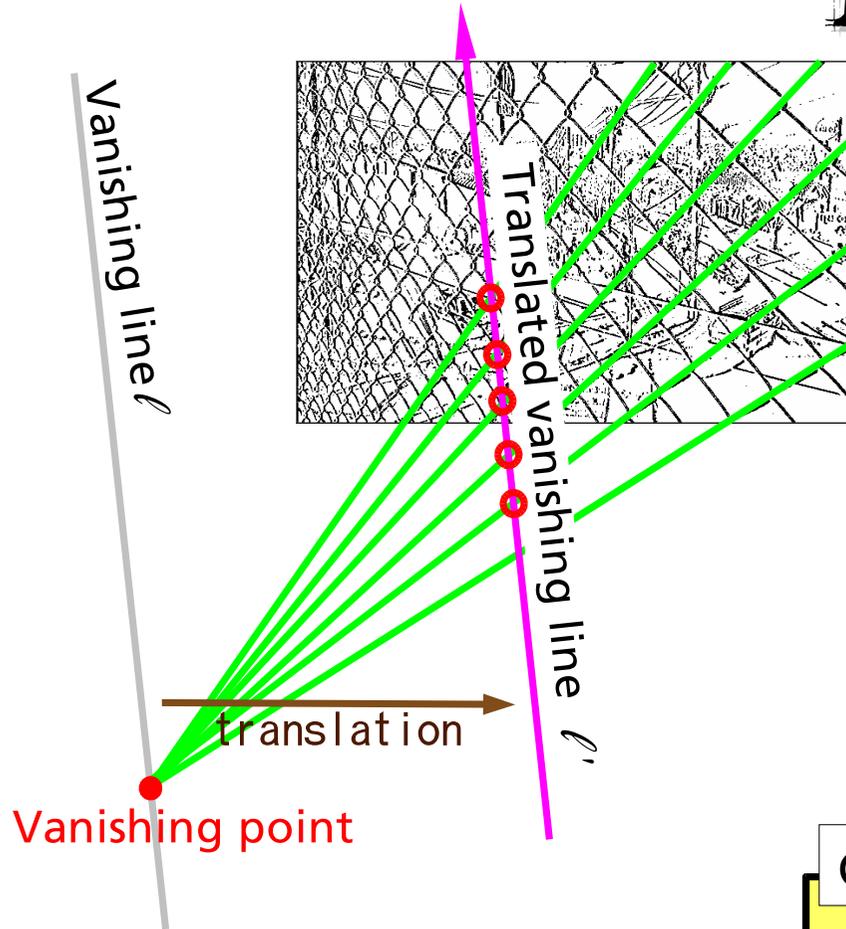
$\epsilon_{ij}$  : distance

### Estimated vanishing point

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

$$i^* = \operatorname{argmin} \operatorname{med} \epsilon_{ij}$$

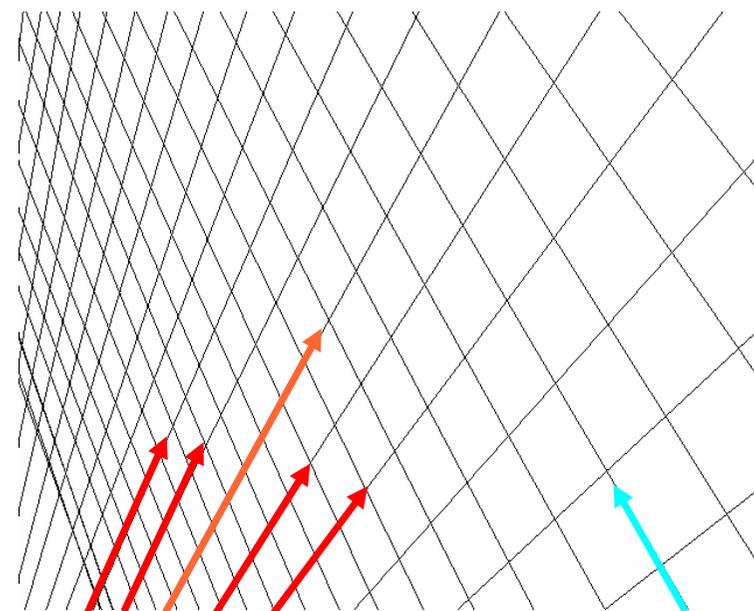
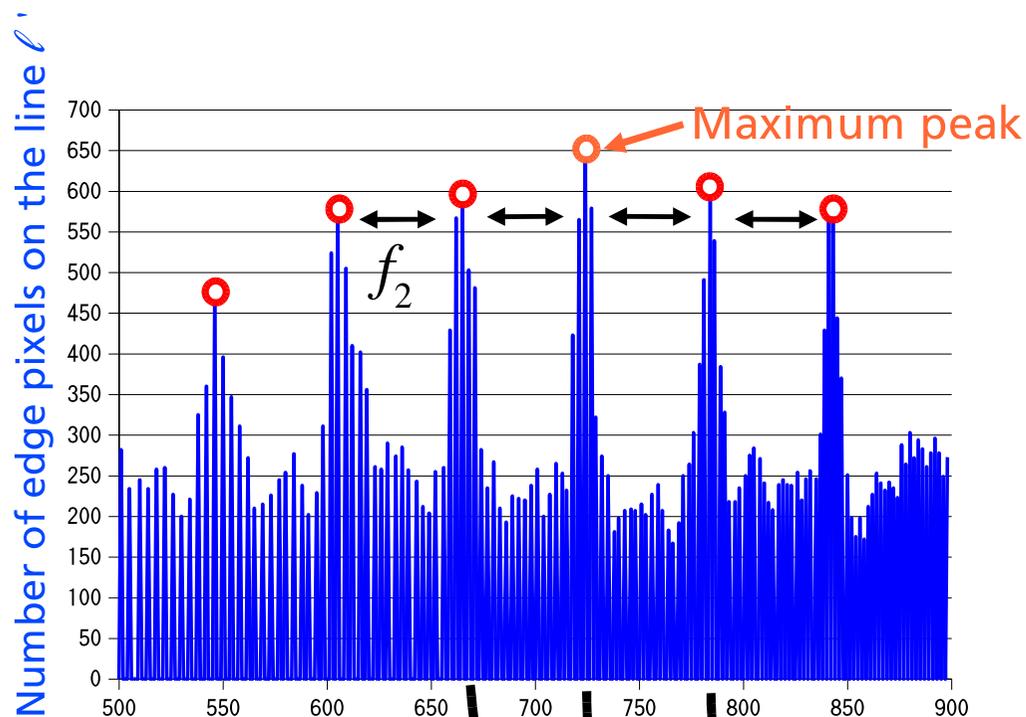
# Accumulation on the Translated Vanishing Line



Counting edge pixels on the line  $l'$

The intersections of  $l'$  and the fence lines have the equal interval.

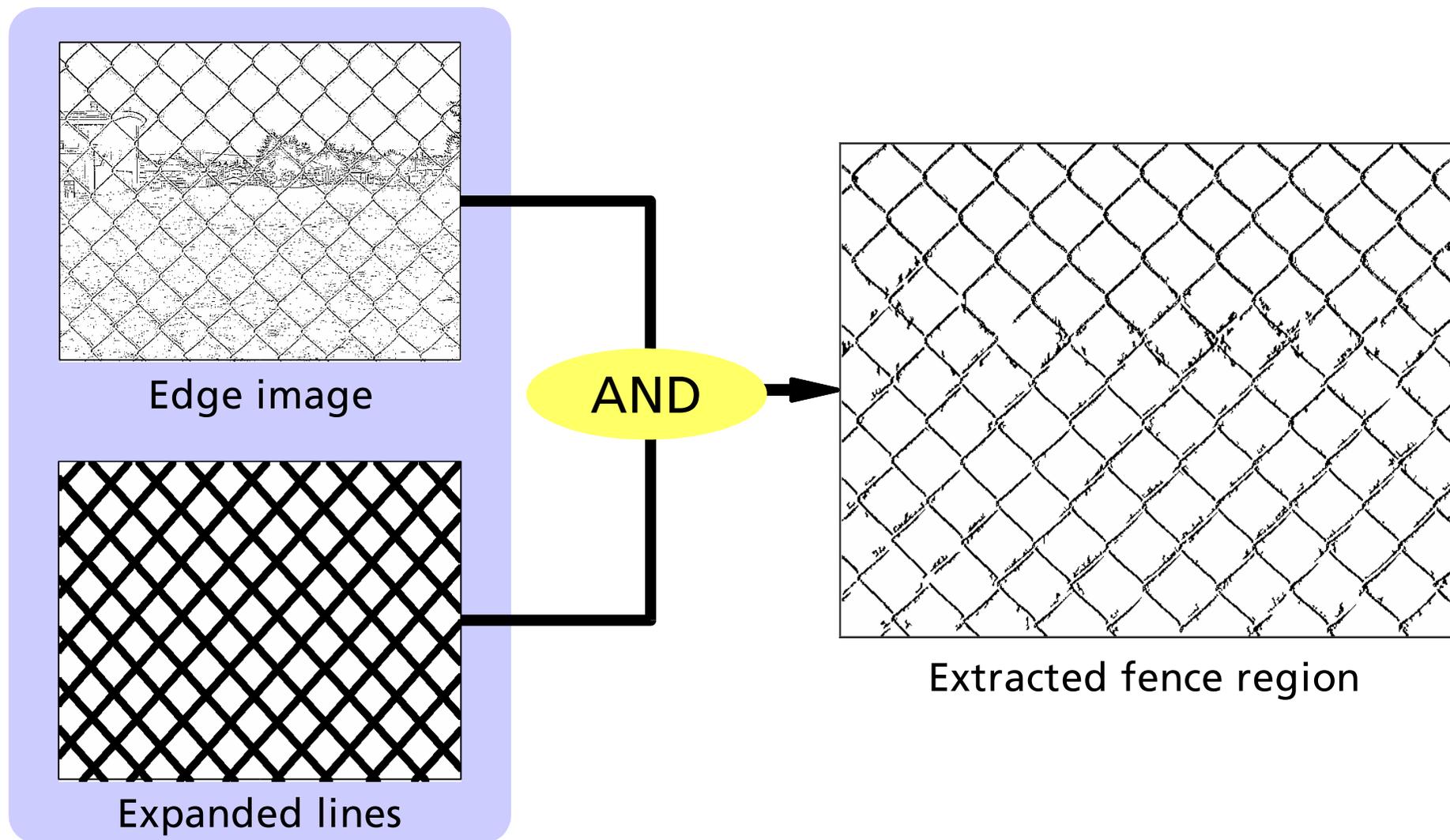
# Localizing Lines on the Fence



Same method for another set of lines

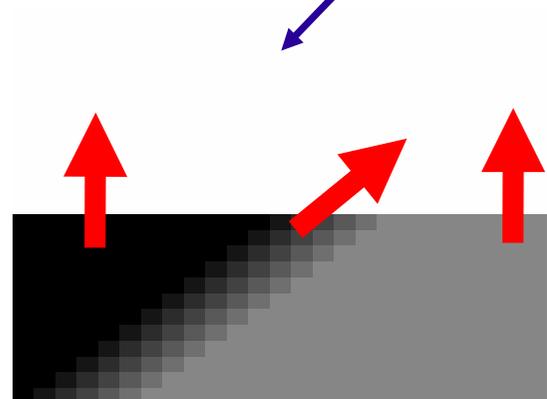
Hough space

# Extraction of Fence Region



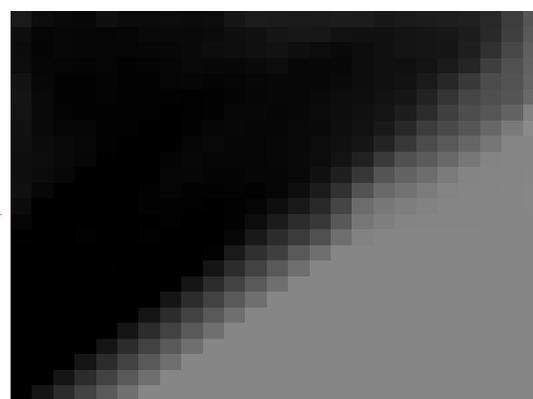
# Disoccluding Fence Region

region to be removed



before

diffusion



after

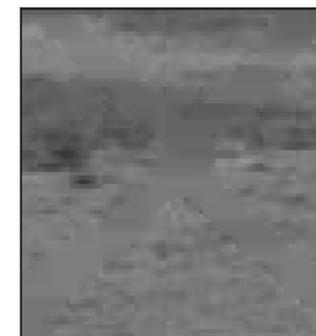
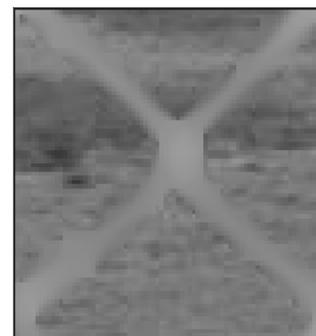
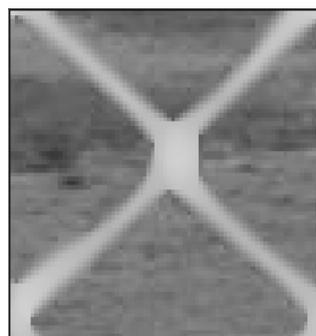
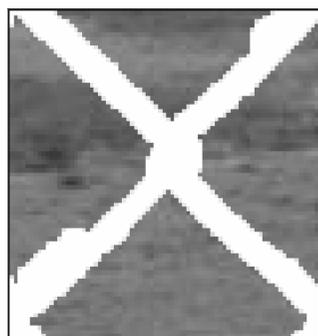
Inpainting equation :

$$I_t = \nabla(\Delta I)\nabla^\perp I$$

$I$  : Image

$\nabla^\perp I$  : edge orientation

(M.Bertalmio, 2000)



# Experimental Results

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**Parallel case**

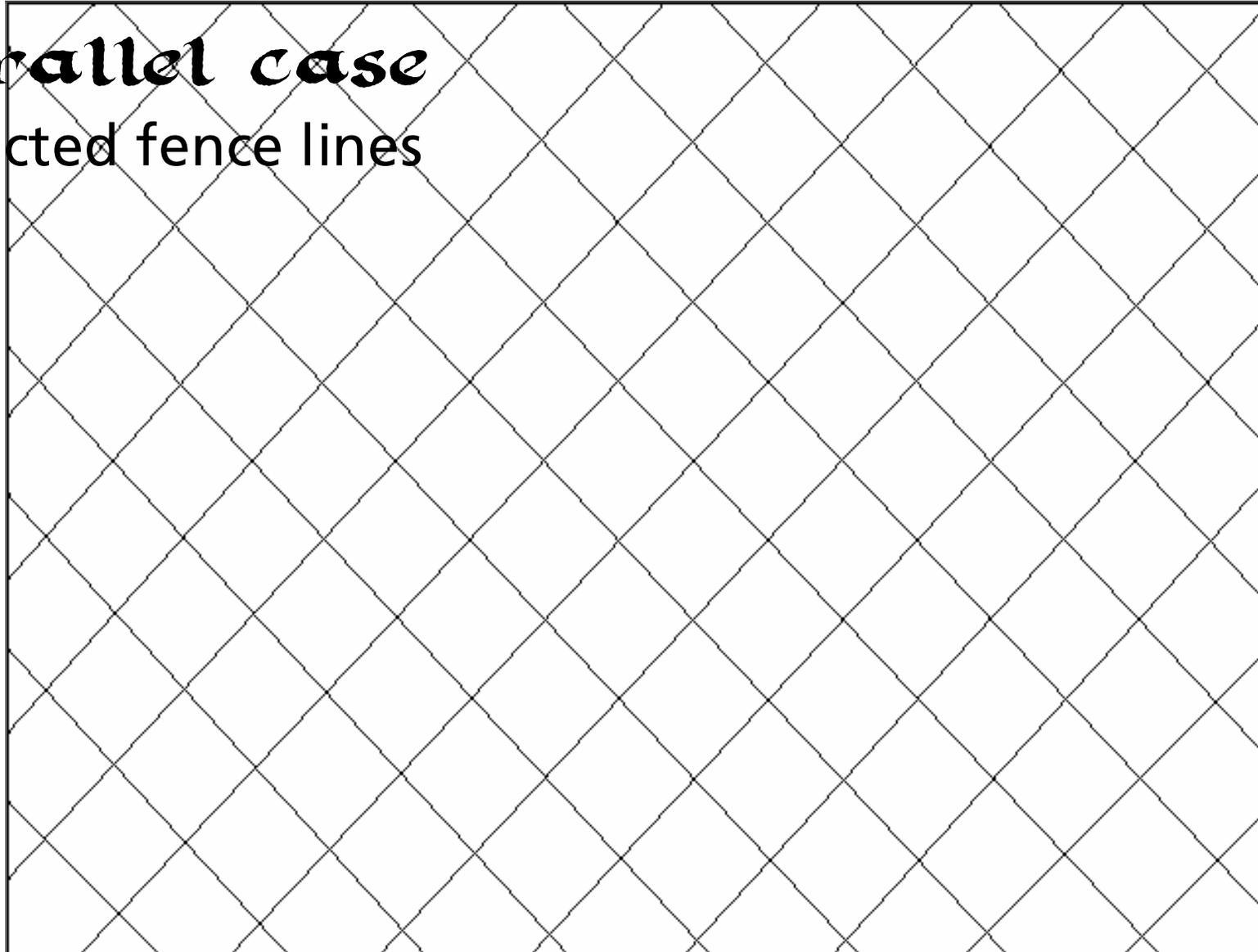
original image (640x480)



# Experimental Results

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**Parallel case**  
extracted fence lines



# Experimental Results

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*Parallel case*

fence removed



# Experimental Results

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*Parallel case*  
background restored



# Experimental Results

**Non-Parallel case**  
original image (640x480)

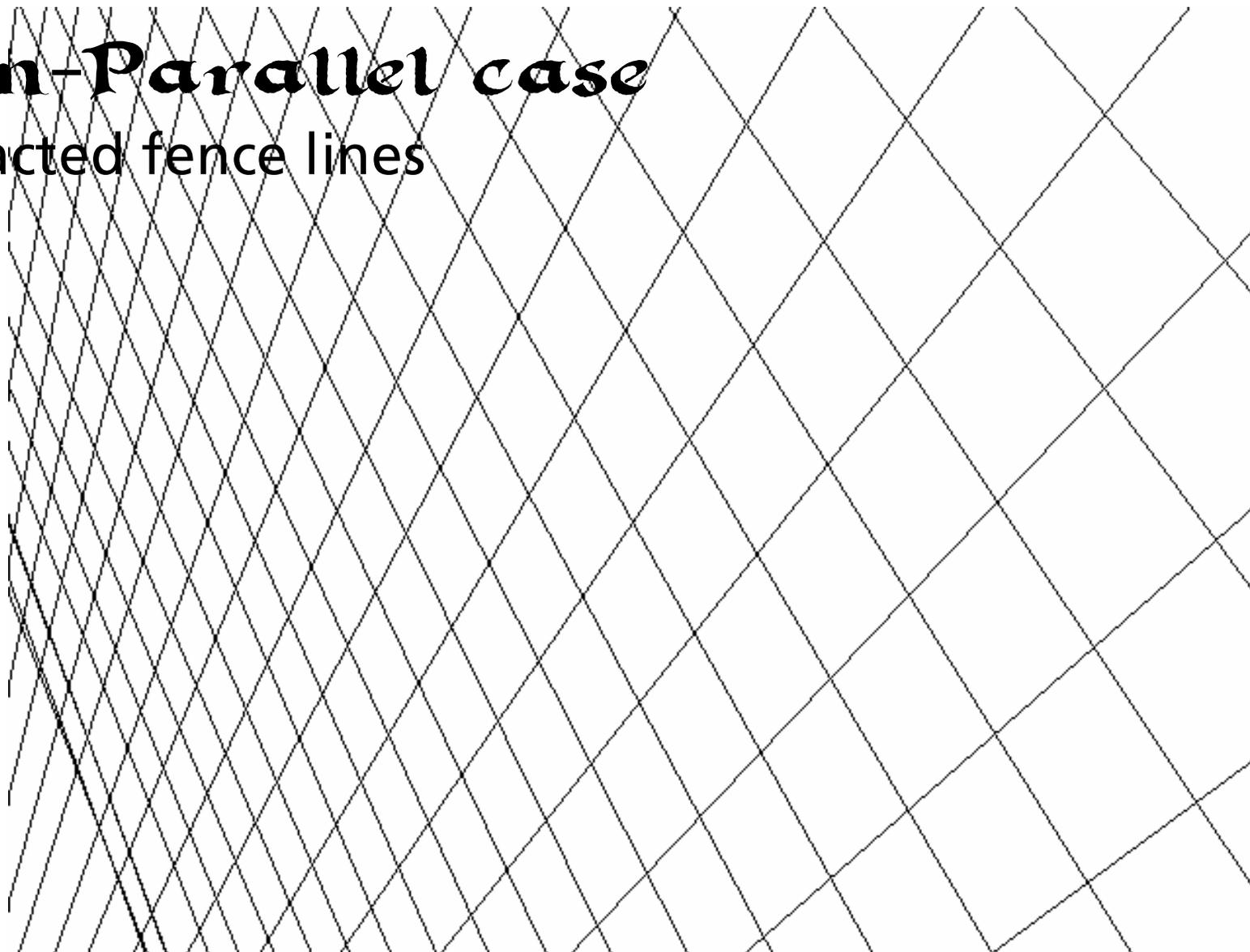


# Experimental Results

NIIGATA UNIVERSITY

## ***Non-Parallel case***

extracted fence lines



# Experimental Results

**Non-Parallel case**

fence removed



# Experimental Results

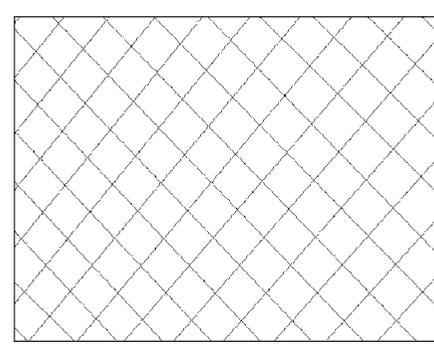
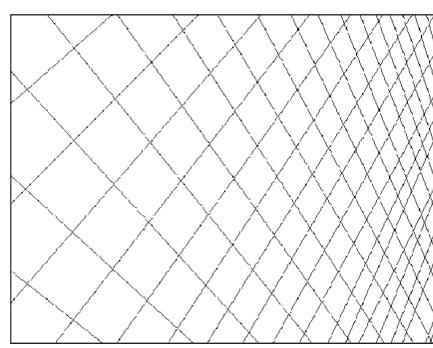
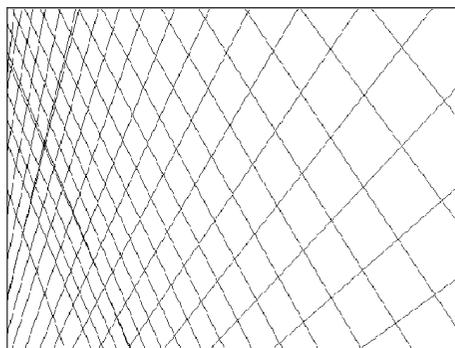
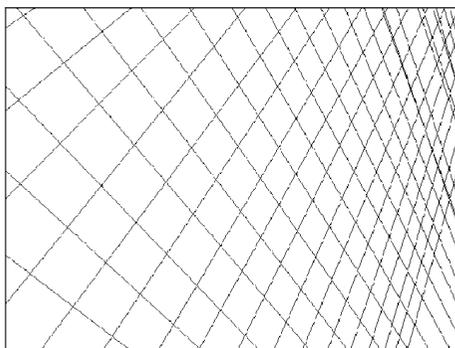
**Non-Parallel case**

background restored



# Experimental Results

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# 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