VENUS TRANSIT 2004
and IMAGE PROCESSING

Stanislava Šimberová
mailto:ssimbero@asu.cas.cz

May 7, 2004
OUTLINE

- Goals of Image Processing in the VT-2004 Project
OUTLINE

- Goals of Image Processing in the VT-2004 Project
- Skeleton of the Pipeline
OUTLINE

• Goals of Image Processing in the VT-2004 Project

• Skeleton of the Pipeline

• Image Enhancement
OUTLINE

• Goals of Image Processing in the VT-2004 Project

• Skeleton of the Pipeline

• Image Enhancement

• Image Restoration and Analysis
OUTLINE

• Goals of Image Processing in the VT-2004 Project

• Skeleton of the Pipeline

• Image Enhancement

• Image Restoration and Analysis

• Additional Mathematical Operation and Distance Computation
DIGITAL IMAGE PROCESSING

is used for three fundamental purposes:

-improving the visual appearance of images to a human viewer
DIGITAL IMAGE PROCESSING

is used for three fundamental purposes:

- improving the visual appearance of images to a human viewer

- preparing images for further analysis
DIGITAL IMAGE PROCESSING

is used for three fundamental purposes:

- improving the visual appearance of images to a human viewer

- preparing images for further analysis

- investigating hidden information in the image
In the image processing chain:
In the image processing chain:

- menu of the methods
In the image processing chain:

- menu of the methods

- INFO + EXAMPLES
In the image processing chain:

- menu of the methods

- INFO + EXAMPLES

- application to the real image fits, gif, jpeg
USER REGISTRATION

NAME

PASSWD

e-mail

REGISTRATION CONFIRMED

MAIN PAGE MENU
Professional observatories

ONDREJOV //asu.cas.cz/~sunwatch
PARIS link to http:// ...
ESO link to http:// ...
TENERIFE link to http:// ...
...etc.
PLACES of observation

A 1
A 2
A 3
A 4
.....

http://proxyon.asu.cas.cz/~venus

– amateur observations

MAIN PAGE MENU
MENU – processing methods

IMAGE ENHANCEMENT

- CONTRAST manipulation
- HISTOGRAM modification
- NOISE cleaning
- EDGE crispening
MENU – processing methods

IMAGE ANALYSIS

EDGE detection

<table>
<thead>
<tr>
<th>Method</th>
<th>INFO</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREWITT</td>
<td>INFO</td>
<td>Example</td>
</tr>
<tr>
<td>SOBEL</td>
<td>INFO</td>
<td>Example</td>
</tr>
<tr>
<td>ISOTROPIC</td>
<td>INFO</td>
<td>Example</td>
</tr>
<tr>
<td>LAPLACE 1</td>
<td>INFO</td>
<td>Example</td>
</tr>
<tr>
<td>LAPLACE 2</td>
<td>INFO</td>
<td>Example</td>
</tr>
<tr>
<td>CONE</td>
<td>INFO</td>
<td>Example</td>
</tr>
</tbody>
</table>
### MENU – processing methods

#### Aditional math. operation

<table>
<thead>
<tr>
<th>Operation</th>
<th>INFO</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subtraction</td>
<td>INFO</td>
<td>Example</td>
</tr>
<tr>
<td>Addition</td>
<td>INFO</td>
<td>Example</td>
</tr>
<tr>
<td>Multipl./divis.</td>
<td>INFO</td>
<td>Example</td>
</tr>
<tr>
<td>Statistics</td>
<td>INFO</td>
<td>Example</td>
</tr>
<tr>
<td>Histogram</td>
<td>INFO</td>
<td>Example</td>
</tr>
</tbody>
</table>

#### DISTANCE computation
DISTANCE COMPUTATION

ONDREJOV observatory

FULL DISC OBSERVATION in $H\alpha$ and white light

DISTANCE Venus (barycenter)
SUN (limb or center)

OWN OBSERVATION

Data acquisition page

Demands for observ.

Bad examples

insert image + text.file
\[ a = r \frac{(x_v - x_t)}{(x_s - x_t)} = r \frac{(y_v - y_t)}{(y_s - y_t)} \]
EXAMPLES OF THE NON–ACCEPTED IMAGES

SOLAR LIMB

VENUS
IMAGE ENHANCEMENT and ANALYSIS

• consisting of various techniques that seek to improve the visual appearance of an image
IMAGE ENHANCEMENT and ANALYSIS

• consisting of various techniques that seek to improve the visual appearance of an image

• preprocessing methods to prepare an image for analysis
IMAGE ENHANCEMENT and ANALYSIS

- consisting of various techniques that seek to improve the visual appearance of an image

- preprocessing methods to prepare an image for analysis

- the basis of linear filtering is convolution theorem

\[ g(x, y) = f(x, y) * h(x, y) \]
Basic Scheme of Digital Image Processing

Spatial domain

- Discrete image in spatial domain: $f(x,y)$
- Processing in spatial domain
- Processed image in spatial domain: $g(x,y)$

Transform domain

- Discrete image in transform domain: $F(u,v)$
- Processing in transform domain
- Processed image in transform domain: $G(u,v)$

Transforms:
- FFT
- IFFT
\[ f(x, y) \ast h(x, y) \iff F(u, v) \cdot H(u, v) \]

\[ f(x, y) \cdot h(x, y) \iff F(u, v) \ast H(u, v) \]

The discrete convolution equation

\[ G(j,k) = \sum_m \sum_n F(m,n) \cdot H(m-j-C, n-k+C) \]

where \( G(j,k) \) – filtered output image

\( F(j,k) \) – input image

\( H(j,k) \) – impulse response array \( L \times L \) size

\[ C = (L + 1) / 2 \]
Image matrix

Image $f(x,y)$

Mask

Mask coefficients

Pixels of image under mask

$g(x,y) = \sum \sum h(k,l)f(x-k,y-l)$
CONTRAST manipulation

special transfer functions

\[ f_1, f_2, \ldots, f_8 \]

different range of density

HISTOGRAM modification

EQUALIZATION

- based on cumulative histogram

\[ \rightarrow \text{to enhance contrast by the uniform distribution of density, but the details are preserved} \]
NOISE cleaning

additive noise $\rightarrow$ discrete isolated pixel variations

$\rightarrow$ cleaning algorithms are based on spatial operations performed on local neighborhoods of input pixel

$\rightarrow$ LOW−PASS FORM of the impulse response

N 1, N 2, ......, N 9
Smoothing, Median, Gauss, Min, Max, ...

EDGE crispening

an image with accentuated edges is more pleasing than exact photometric reproduction

$\rightarrow$ convolution with HIGH−PASS FORM of the impulse response

E 1, E 2, .... , E 5
Masks of the high−pass filters, Sharp, Point, Tent, ...
IMAGE ANALYSIS

data extraction, image description, segmentation, scene analysis

EDGE detection

Edges characterize object boundaries.
Edge, line and spot locations are specified by dark pixels against a light background.

Methods based on

- the first order derivative of an image function
  ROBERTS, PREWITT, SOBEL, FREI–CHEN, ...
  involve generation of gradients in two orthogonal directions.
  D 1, D 2, D 3

- the second order derivative
  LAPLACE (4, 8 neighbor; Laplacian of Gaussian)
  An edge is marked if a significant spatial change occurs in the 2nd derivative.
  D 4, D 5, D 6
MERCURY TRANSIT

2003-05-07 Ondřejov
Czech Rep. 09:21:02 UT
MERCURY TRANSIT

2003-05-07  Ondřejov  Czech Rep.  09:21:02 UT  10%
MERCURY TRANSIT

2003-05-07  Ondřejov
Czech Rep.    08:43:26 UT
Prewitt operator
Prewitt operator
Sobel operators horizontal, vertical
Result of Sobel operators
Prewitt operators horizontal, vertical
Result of Prewitt operators
Result of Laplace1 operator
IN ASTRONOMY YOUR IMAGE IS EVERYTHING.

ONE PICTURE IS WORTH MORE THAN TEN THOUSAND WORDS.

Anonymous