

## Detection of spatial reference objects for automatic orientation of arbitrary arranged metric images

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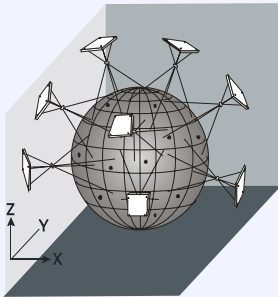
Boochs

## Detection of spatial reference objects for automatic orientation of arbitrary arranged metric images

- **motivation**
- **conception**
- **aspects of solution**
- **data processing**
- **practical aspects**
- **examples**

area of application:

**image based surveying of spatial objects**



needs:

**determination of orientation values for all  
images to be used**

is based on:

**image rays to tie and control points**

area of application:

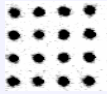
**image based surveying of spatial objects**



collection of image rays by means of:



manual identification and measurement  
of natural object points



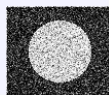
computer based detection of artificial signals



signals are:

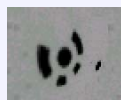
- templates of a certain diameter
- used to define a point (centre)
- not used with their spatial data (diameter, area)

reduction of success due to:



- image noise

in particular for arbitrary arranged images:



left view



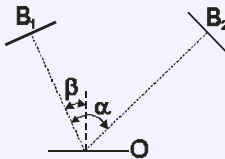
right view

- perspective distortion

### conventional ways of compensation:

- **image noise:**

improvement of S/N ratio (sensor, light,...)



- **distortion:**

limitation of angular differences

- for optical axes of different images
- for surface normal and individual optical axis

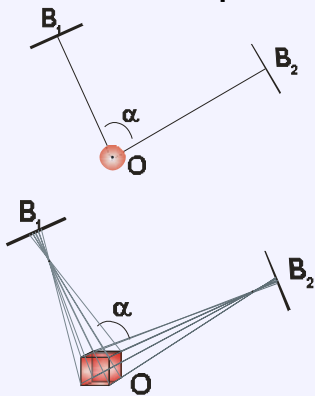
### compensation leads to increasing effort:

- increasing number of images
- increasing number of signals

### in cases of reduced success consequences have to be expected:

- quality of image rays is degraded
- reduced connection between images
- failure to connect two images

idea: improvement of connectivity be means of **spatial tie objects**



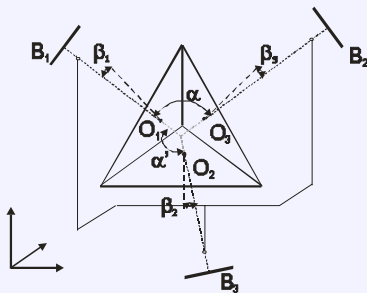
**sphere:**

- substitutes target plane
- visible from all directions
- defines one image ray

**body with n faces:**

- defines multiple target planes
- visible from all directions
- defines several image rays
- introduces additional information (scale, local co-ordinate system, orientation in space)

we use of spatial tie objects with several faces



**advantages :**

- multiple surfaces useable
- at least one surface with a small angle to the optical axis
- allows completely new arrangements

essential requirement which has to be fulfilled:

**the targets have to be treated and detected as  
complete spatial objects**



- the whole body (= all visible surfaces) has to be detected
- visible surfaces have to be uniquely identified
- all surfaces need to have a fix and known topology

type of target chosen: **cube**



because of its:

- symmetry
- equal size of faces
- number of faces
- angular difference of adjacent faces

discrimination of individual surfaces by means of :



### coloring

because:

- information is pixel based
- sufficient number of separable colors available (red, green, blue, cyan, magenta, yellow)

discrimination of individual surfaces by means of :

### alternative: active lighting



because:

- independent of ambient light
- easier analysis of colour values
- more robust

further benefit:



### simple geometry

- simplifies modelling within different stages of analysis
- allows to introduce effective constraints

general algorithmic structure:

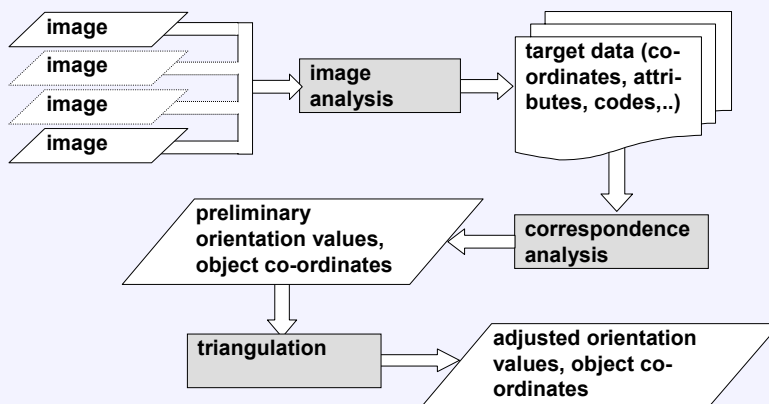




image analysis steps:

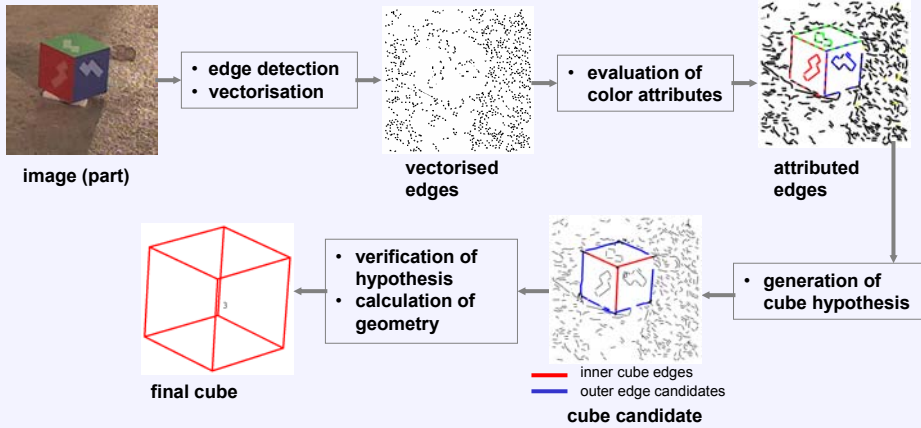
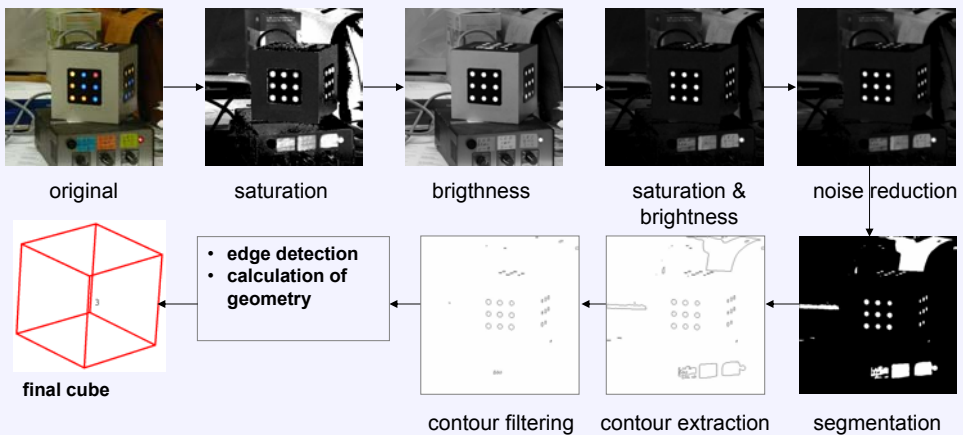


image analysis steps (active lighting):



further steps:

### correspondence analysis

simplified by:

- grouping of points
- geometry constraints
- target knowledge

### image triangulation

based on standard algorithms:

actually : CAP

### color information

- simplifies detection
  - provides binary code
  - characterizes shape / relation of sides of targets
- for passive coding:
  - **may vary considerably (direction of illumination, type of light, sensor characteristic and state)**
- for active coding:
  - **luminosity and homogeneity need to be controlled (overexposure, reaction of sensor)**

### size of targets

- has to be sufficient
  - size of faces
  - geometric quality of edges
- has to be considered with respect to possibly strong variations within image scale

### spatial characteristic of targets

- provides useful information within analysis
  - parallel edges
  - right angles at adjacent edges
  - constant edge length
- introduces scale into image block
- further distances only for quality check
  - each cube allows to define 2 groups of 2 distances in each direction of space
  - distances are scattered over object space together with targets

### **benefits from spatial shape of targets (spatial extent)**

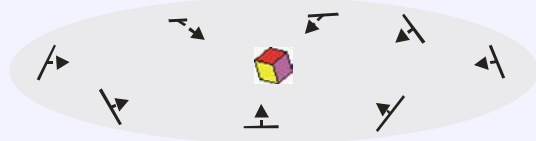
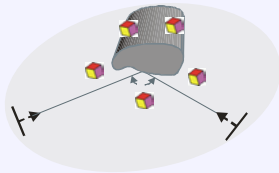
- each target may define a local co-ordinate system
  - > allows orientation to a local system without any further preparations within object space
- already one target provides data for preliminary orientation
  - > allows to estimate orientation values for images in a common system

### **benefits from spatial shape of targets (multitude of image rays)**

- rays of each target are covering a local image area
  - > provides control information for local image geometry
- each target is represented by 8 rays
  - > gives redundancy and allows to control quality of each point

### benefits from independence of viewing direction

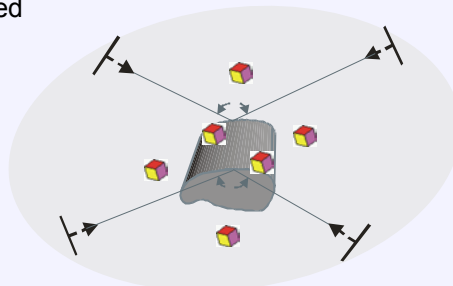
- provides deepest connection of images possible
  - > all images will be connected having sight onto a certain target



- allows to optimize image arrangements simply from viewpoint of best geometry
  - > constraints coming from sight onto tie points are reduced

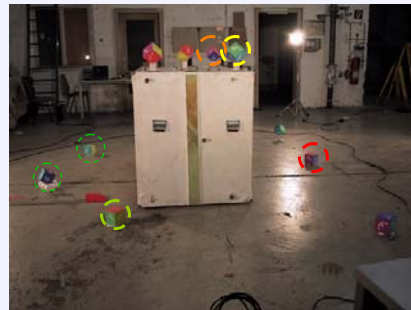
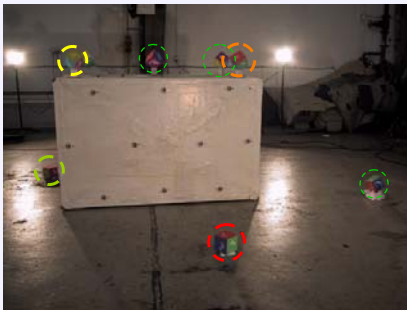
### benefits from independence of viewing direction

- allows complete new image arrangements
  - > images with opposite viewing directions might be combined



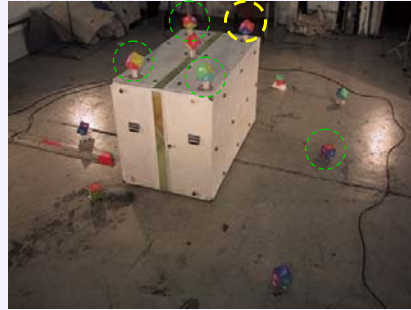
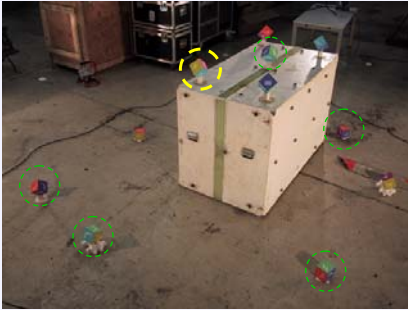
### fields of application

- industrial measurements
- forensic tasks
- facility mapping
- architecture
- stereoscopic visualisation (->consumer market)



**test:** pair of images with 90° convergency

 **4 common targets used**



**test:** pair of images with opposite viewing directions

orientation performed with minimal data (1 target)

