APImondia 41st congress 15 - 20 september 2009 - Montpellier – France. Posters of beekeeping technology and quality commission.

GEOMATIC TECHNIQUES FOR HIVE METRIC AND SEMANTIC DESCRIPTION

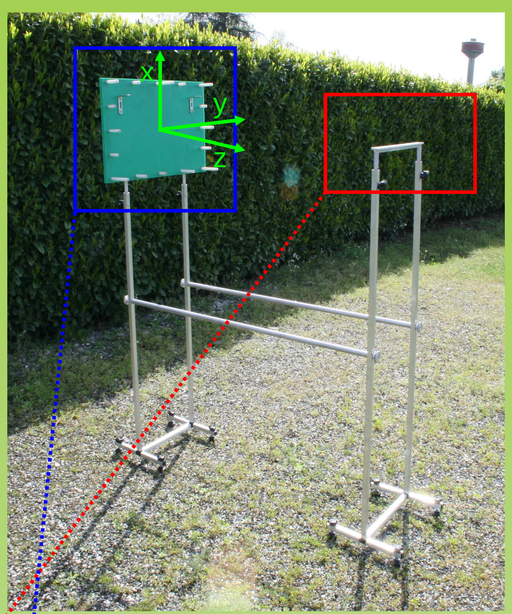
M. Vercelli[1], A. Manino[1], A. Patetta[1], E. Borgogno Mondino[2], M. Anibaldi Ranco[2], M. Porporato[1]

(1) Dipartimento di Protezione e Valorizzazione delle Risorse Agroforestali, Università degli Studi di Torino – Via Leonardo da Vinci 44 – 10095 Grugliasco (Torino), Italia. E-mail: monica.vercelli@unito.it
(2) Dipartimento di Economia, Ingegneria Agraria, Forestale e Ambientale, Università degli Studi di Torino – Via Leonardo da Vinci 44 – 10095 Grugliasco (Torino), Italia.

While assessing hive strength it is a common approach to consider the area of comb, brood, and stores, and the number of adult bees. Traditional measurement techniques are generally inaccurate, subjective and tricky. Under the Italian research project "Integration of bee knowledge through the development and calibration of a model for the simulation of the beehive", we investigate the potentialities of a photogrammetric approach performed on digital images, to improve and make more objective such estimations. This research is aimed at analyzing a simplified bi-dimensional processing, based on image warping, and a 3D modelling of the beehive. The 3D model obtains its complete rigorous geometrical description through stereoscopy. Image processing techniques are then applied to extract thematic information.

IMAGE ACQUISITION SYSTEM

A transportable tool to control the geometry of the acquisition was designed and built.
The system is made up of camera(s), camera support, and calibrated comb hosting support.
The configuration allows to satisfy the accuracy requirements, especially along the Z axis direction (the cameras-object line).



Camera

Images are acquired by means of a Canon EOS 30D camera having the following features:

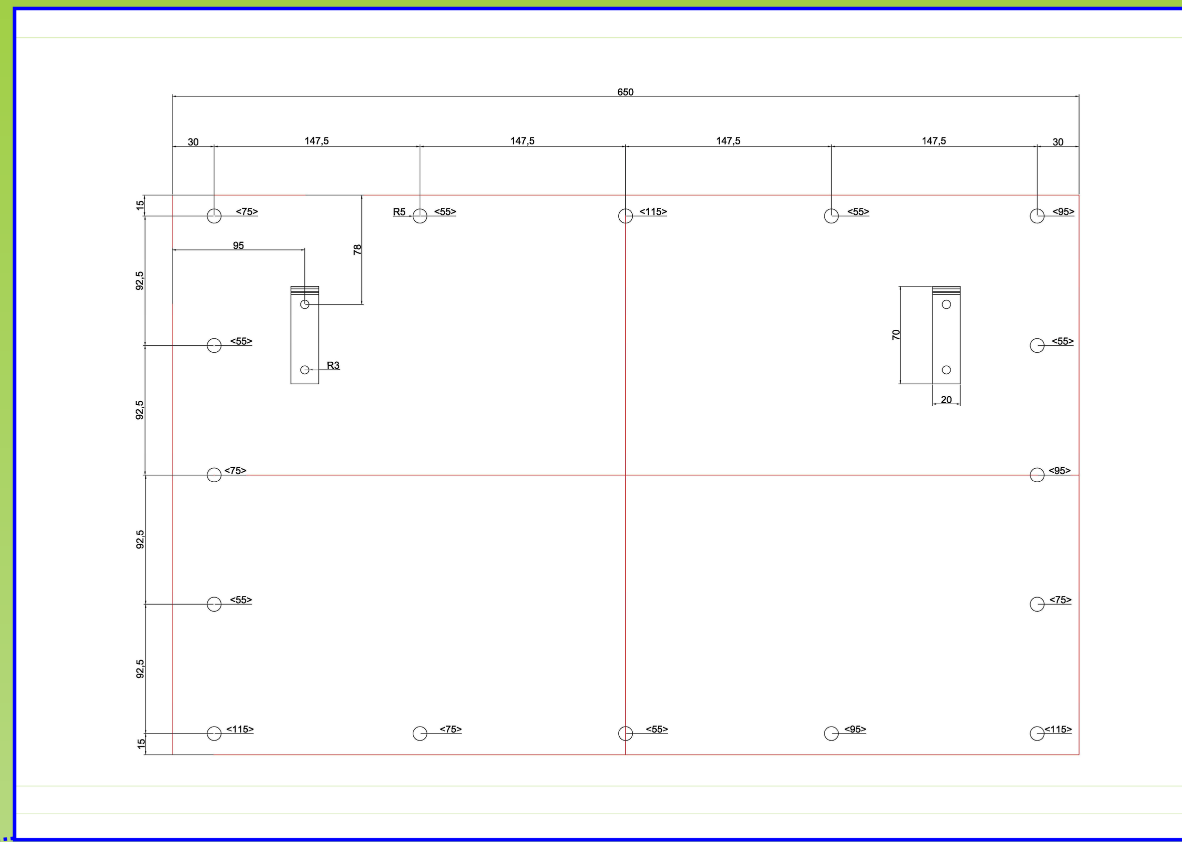
- objective with a fixed focal length EF 35mm
- chip size (CMOS) : 15 mm x 22.5 mm
- physical pixel size: 6.4 µm
- image size: 3504 x 2336 pixels

These features guarantee:

- limited hyper focal distance (about 1.20 m with a diaphragm)
- appropriate geometric resolution: 0.2 mm
- field of view giving the appropriate stereoscopic area at small distances
- low cost (not metric, nor semi-metric camera).

$$res = p \times f \quad \text{where} \quad f = \frac{D}{fl}$$

p = pixel size, *f* = scale factor, *D* = object distance, *fl* = focal length



Camera(s) supporting device

A transverse bar is placed across the system structure to host a single camera or two cameras contemporarily so that they are shot at the same time.
The cameras can move along the bar in order to vary the base of the acquisition.
The bar can be moved forward or backward in respect to the comb hosting support in order to refine, time by time, the camera(s)-object distance, so as to respect as much as possible the theoretical B/H (base/height) ratio allowing close range photogrammetry.

Comb hosting support

Combs are hosted by a green Polizene® panel equipped with calibrated pegs, whose positions are known within a local reference system. Peg number is large enough to solve the exterior orientation of the cameras and, eventually, to auto-calibrate them (estimation of focal length, Principal Point coordinates and radial distortions).

HIVE SURVEY

2D APPROACH (fast but approximate)

MONOSCOPY → No warping; Single camera; Shooting from a single point of view

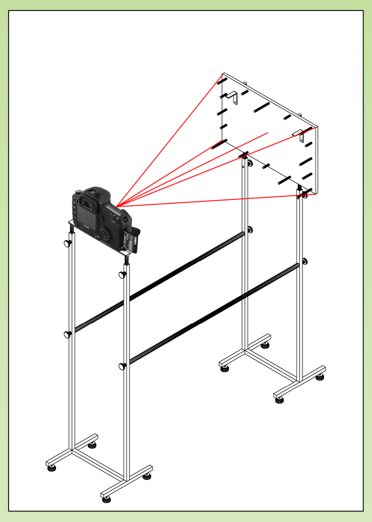
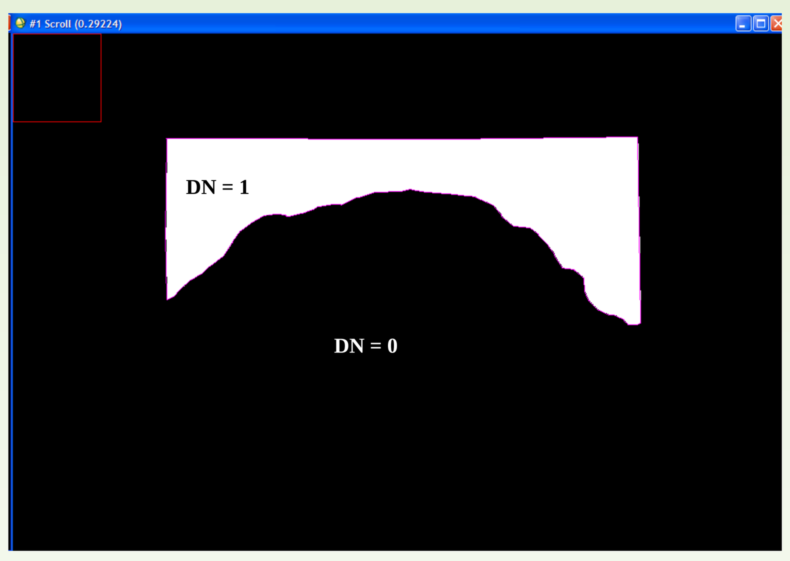
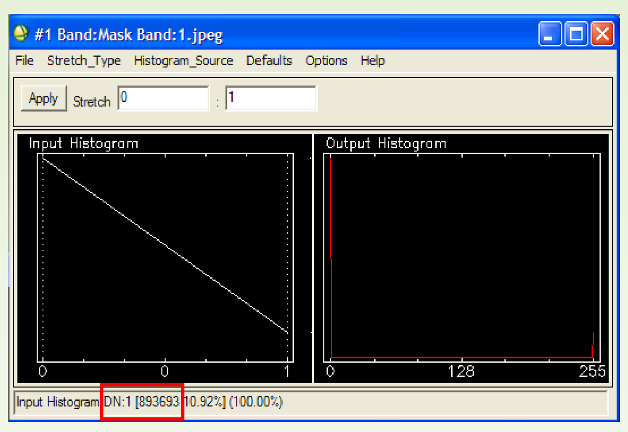


Image Processing

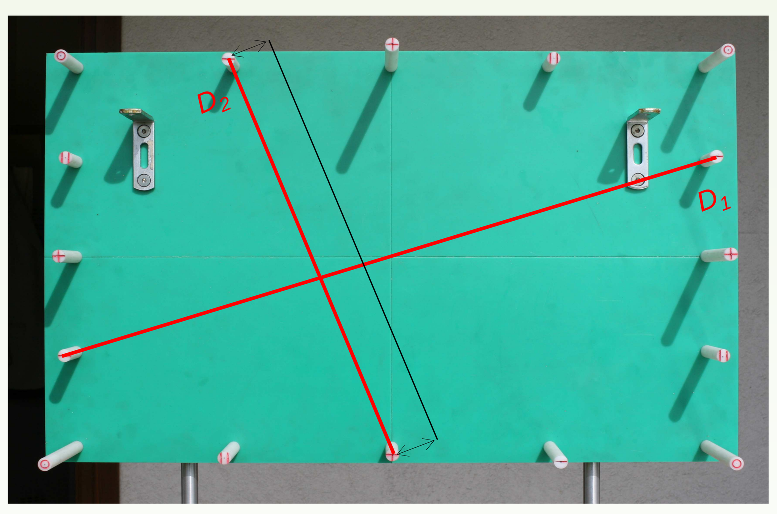
1. Vectorization
The area of honey is outlined using the ENVI 4.2 (ITT) software.

2. Pixel counting
The polygon is used to generate a mask image that is a binary image showing just two digital numbers (DN=1 and 0) defining honey pixels and non-honey pixels, respectively. Honey area is calculated by counting the number of pixels having DN=1.





3. Scale factor recovering.
Pixel size in the real world, needed to convert the number of pixels in an area value, is determined considering the average distance between those pairs of pegs whose height is closest to the comb surface.



$$p = \frac{D}{npixel(D)} \quad \text{where} \quad D = \frac{D_1 + D_2 + .. + D_n}{n}$$

p = pixel metric information
D = observed distance between the pegs on the panel
npixel(D)= number of pixels defining the distance *D* over the image

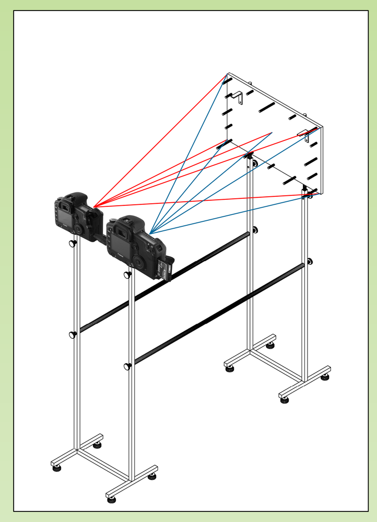
$$A_p = p^2 \qquad Area = N \times A_p$$

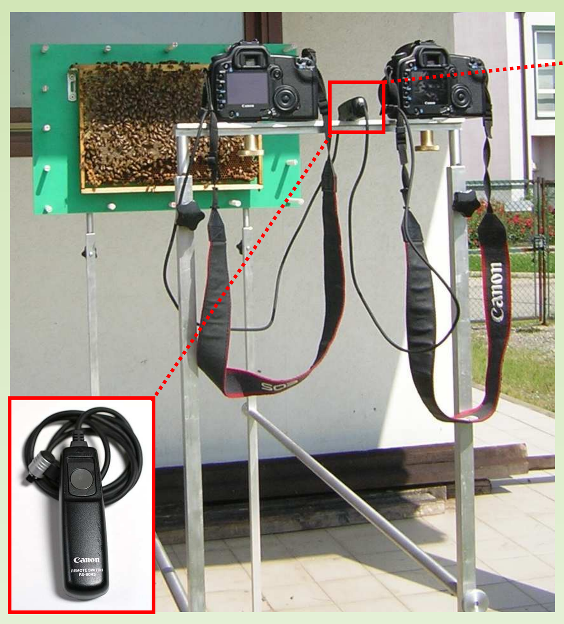
A_p= pixel area
N = number of pixels belonging to generate polygon

3D APPROACH → DIGITAL PHOTOGRAMMETRY

3D measurements of objects can be made by exploiting the artificial stereoscopy. A stereo model is a virtual 3D world in which an expert operator can survey the represented objects.

Stereoscopy can be obtained by imaging the same subject from 2 different points of view; 2 images are required (*stereopair*).





If the subject is a moving one (like honey bees) the stereopair must be acquired simultaneously by means of synchronizing device and remote controller.

Stereo Model Generation

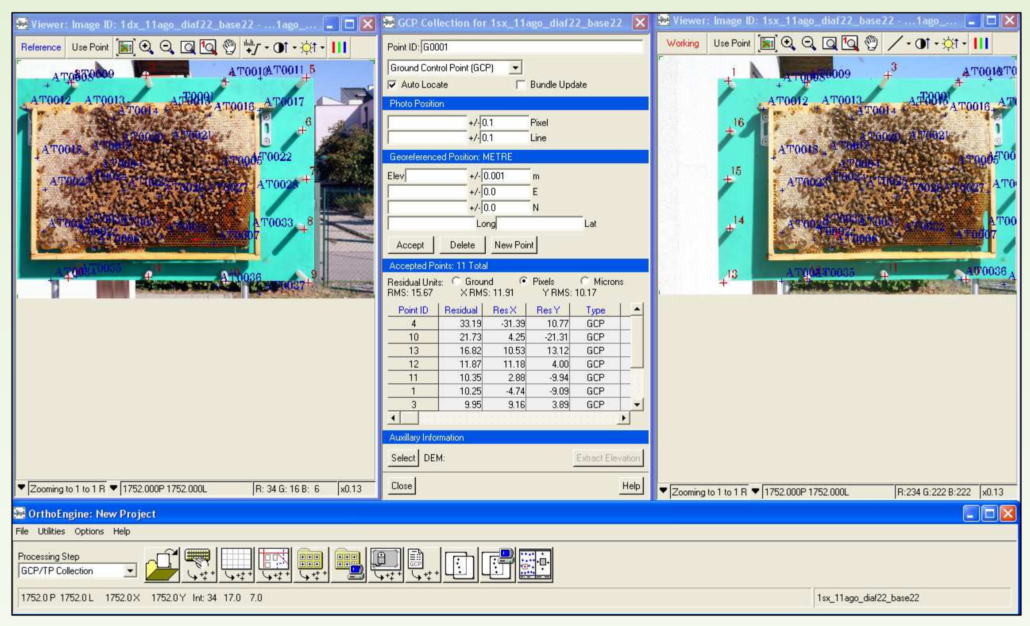
1. Ground Control Point (GCP) collimation (over both the images)

2. Bundle Adjustment aimed at:
- camera auto-calibration;
- image Interior Orientation;
- image Exterior Orientation.

3. 3D operation over the stereo model (*stereo-plotting*) aimed at surveying the comb → vector layers of points, lines and polygons defining rigorously the geometry of the observed object.

Survey Accuracy

The accuracy of the measurements is estimated during the Bundle Adjustment step (based on the GCPs). All the operations were performed using the software *PCI Geomatica 9.1 OrthoEngine*.
Concerning this first attempt no auto-calibration was performed and the nominal values of focal length (*35 mm*) and PPA (*X0 = 0, Y0 = 0*) were assumed. No radial distortion was taken into account.
Under these simplified conditions the resulting accuracy as measured for the GCPs is the following:

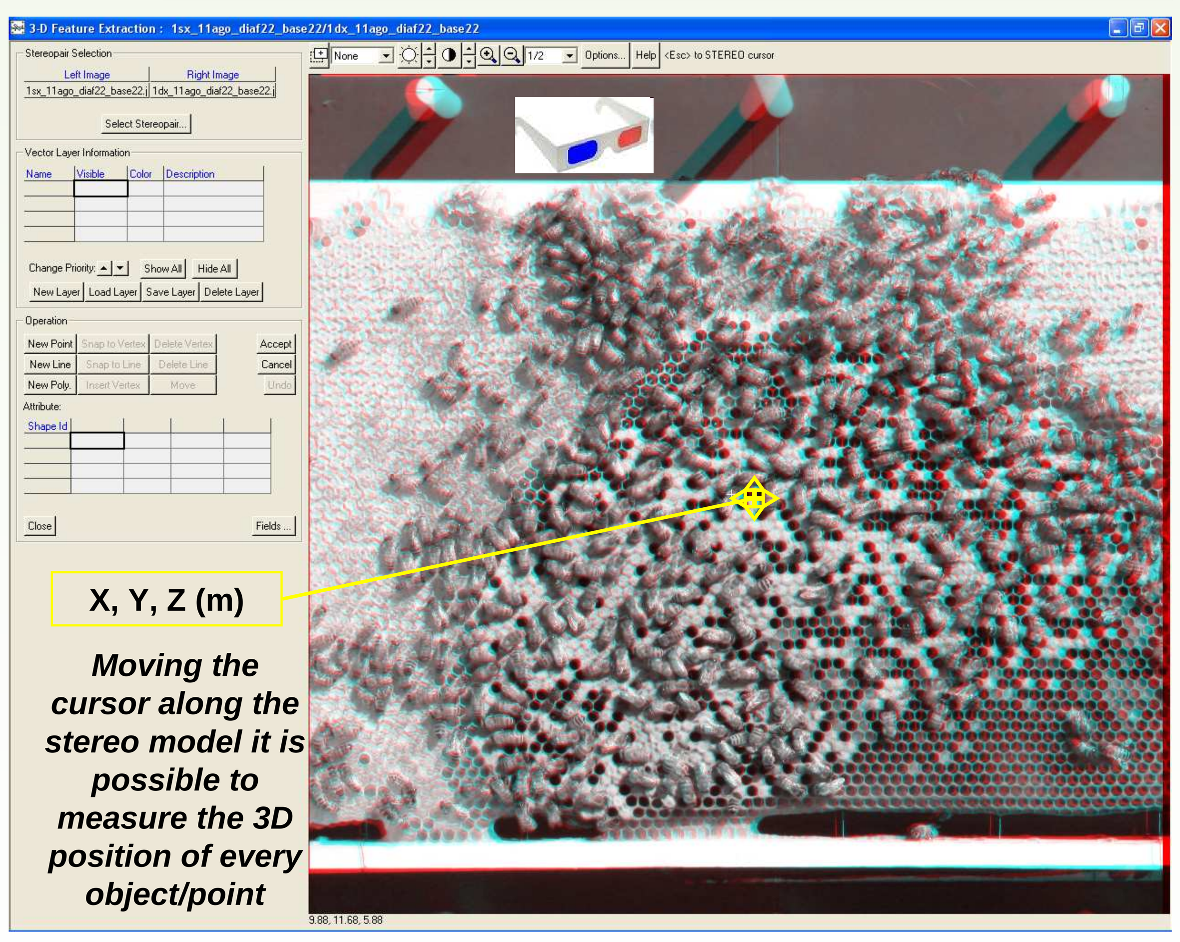


Left image (pixel)	Right Image (pixel)
RMSE_X1 = 55.37	RMSE_X2 = 20.25
RMSE_Y1 = 81.33	RMSE_Y2 = 20.04
RMSE_Z1 = 358. 22	RMSE_Z2 = 298.22

$$RMSE\_ii = \sqrt{\frac{\sum_{i=1}^{N\,GCP} \varepsilon_i^2}{N-1}}$$

$$\text{where} \quad \varepsilon_i = (Xi_{estimated} - Xi_{collimated})$$

RMSE_*ii* = Root Mean Square Error
ε_i= error = difference between the actual value and the predicted value.
Xi $_{estimated}$ = estimated value
Xi $_{collimated}$ = collimated value
N = number of GCPs



Moving the cursor along the stereo model it is possible to measure the 3D position of every object/point

The adopted procedure is the first stage of a prospective methodology that would transform the photographic approach in a photogrammetric approach, and even a stereoscopic one, at present still under investigation. This methodology would be more objective than the traditional ones as it would allow to operate measurements in a uniform way so as to ensure comparability of the obtained values independently from the context and the operator.