GEOMETRICAL CODING AND RECOGNITION OF FULL-COLOR DIGITAL IMAGES

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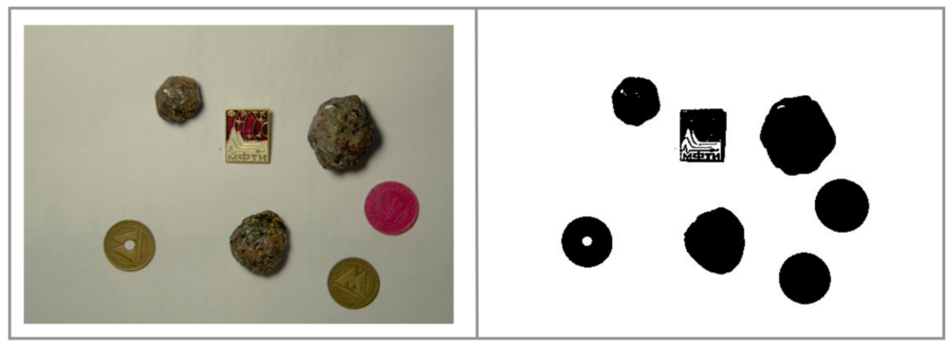
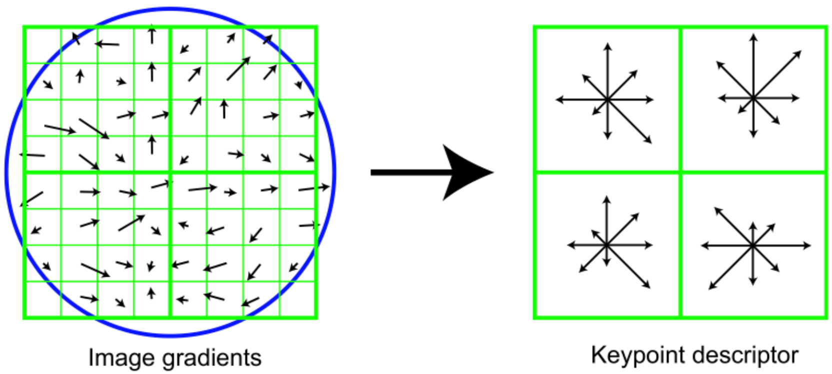
EXISTING METHODS OF ANALYSIS OF DIGITAL IMAGES

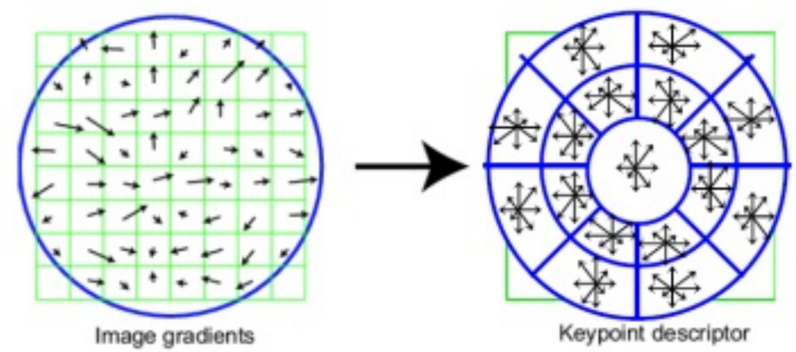
- Commonly color images are preliminary converted to grayscale. Color information is generally lost.



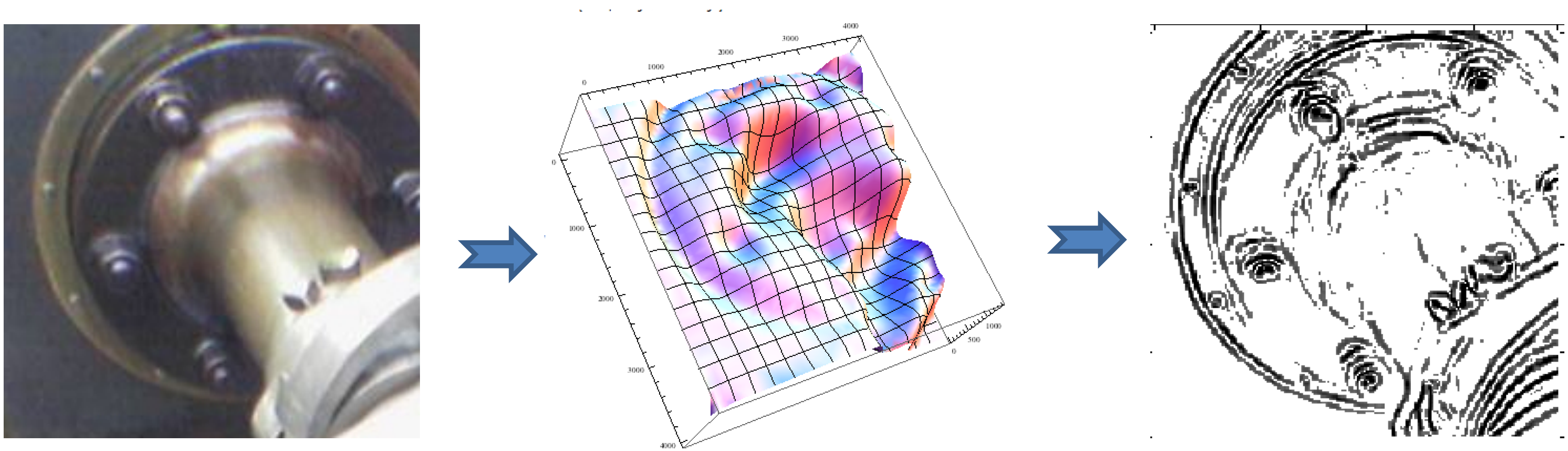
- After that image analysis (recognition, contour detection, comparing, etc.) is based on ***smoothing*** (usually Gaussian), ***gradient*** and ***hessian*** calculations , ***singularities*** ("key points") detection

- ***SIFT*** - scale-invariant feature transform (coding & recognition method)
- ***SURF* -** speeded up robust features (coding & recognition method)





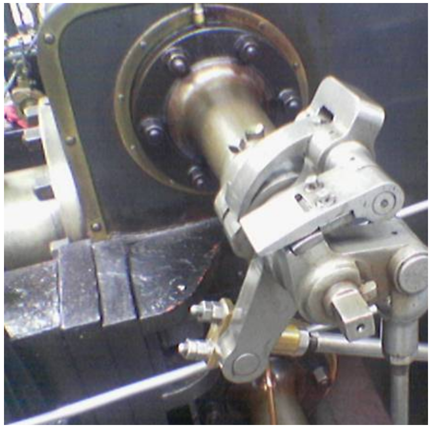
- **GC**

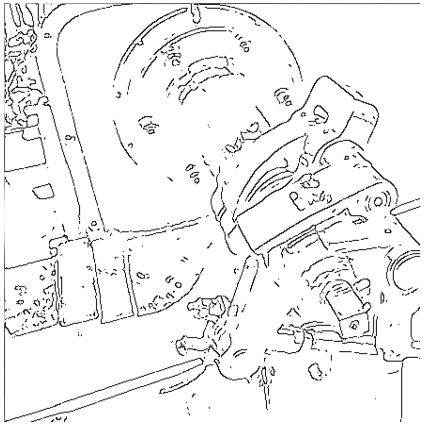


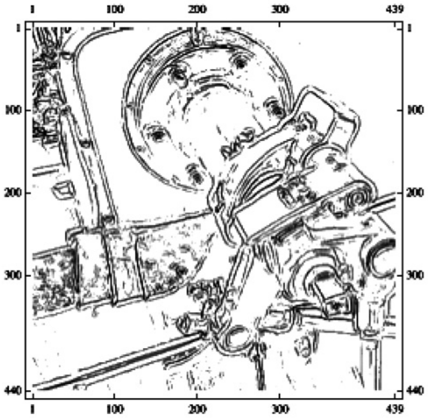
Geometrical coding & contour detection

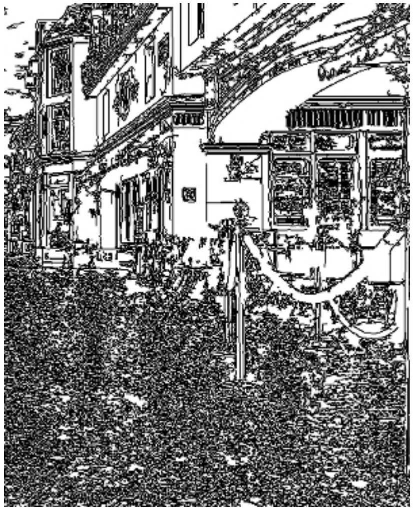
EDGE DETECTION

- ***Canny operator vs GC method***









Canny operator

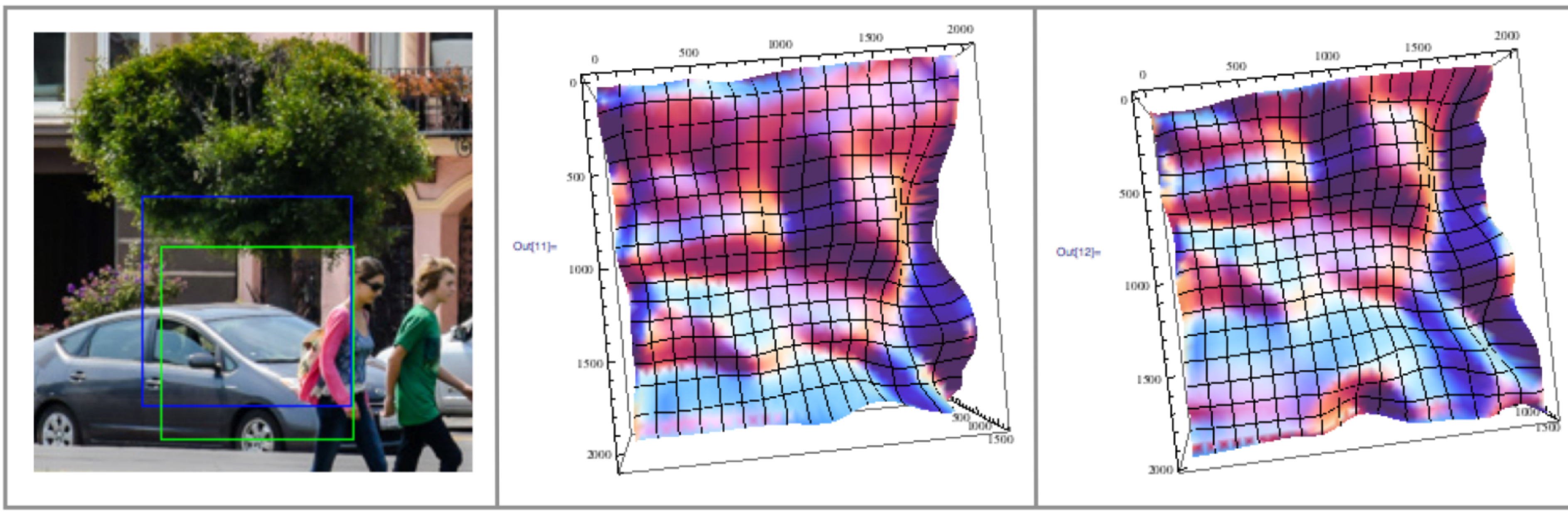
GC detection

GEOMETRICAL CODING METHOD

Step 1. Color digital image is represented by 2D surface in R^3 *without lost of information*. Representation is direct and does not require additional computations.

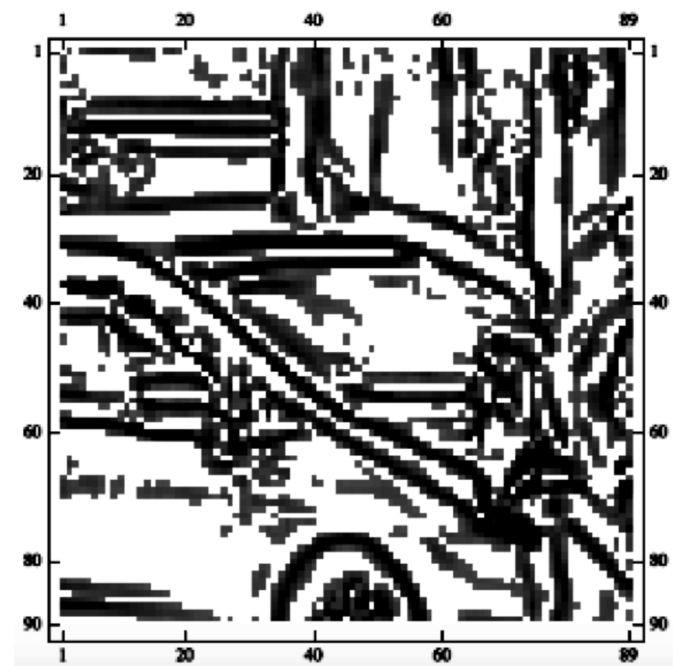
This surface could be very irregular due to noise in the image.

Step 2. Obtained surface (or it's part) is replaced by Bezier (or NURBS) surface. It gives at the same time: *smoothing, noise elimination,* and *radical simplification of calculation of differential-geometric characteristics (tangent plane, curvatures, etc.).*



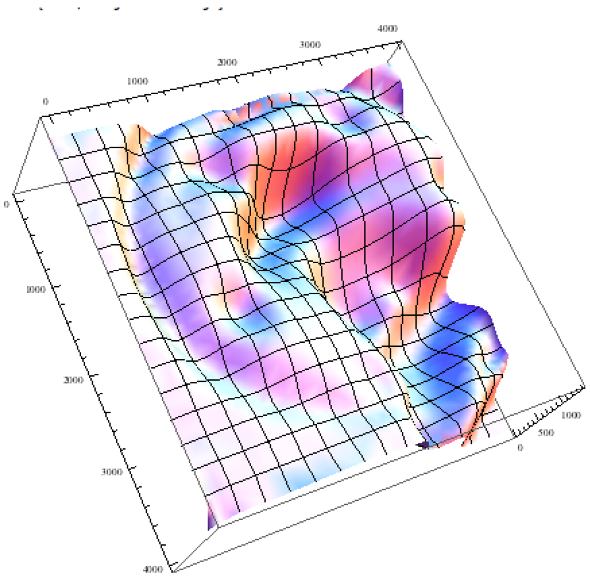
Step 3. The resulting Bezier (or NURBS) surface is simplified to contour picture using principal curvatures (λ_1, λ_2) calculation. Examples:

- $f_1(\lambda_1, \lambda_2) = ||\lambda_2| - |\lambda_1||$; $f_2(\lambda_1, \lambda_2) = |\lambda_2 - \lambda_1|$;
- $f_3(\lambda_1, \lambda_2) = \max(f_1, f_2)$;
- $f_4(\lambda_1, \lambda_2) = \begin{cases} |\lambda_2| / |\lambda_1|, \text{ if } \lambda_2 \geq \lambda_1 \\ |\lambda_1| / |\lambda_2|, \text{ if } \lambda_2 < \lambda_1 \end{cases}$

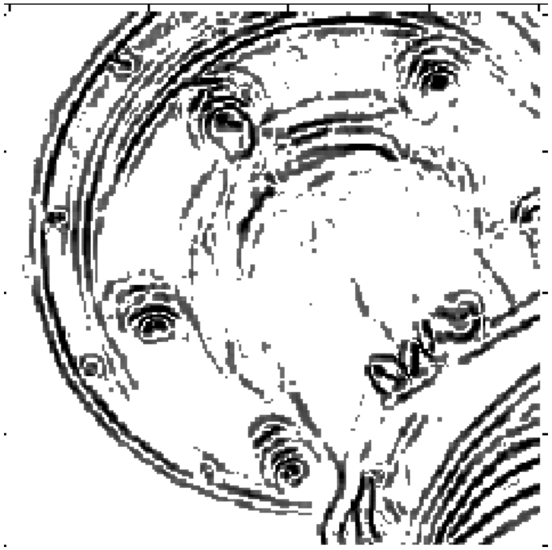


Step 4. Depending on the task, obtained contours are used for recognition purpose, image comparing, edge detection, etc. After rough results are obtained based on contours, they could be tuned based on coding surfaces themselves.

Image



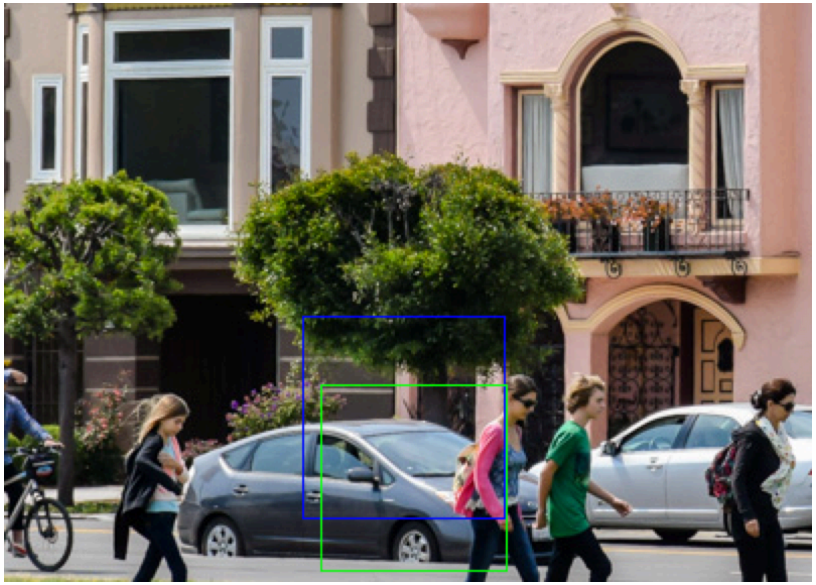
Coding surface



Contours

GC: IMAGE COMPARING & RECOGNITION

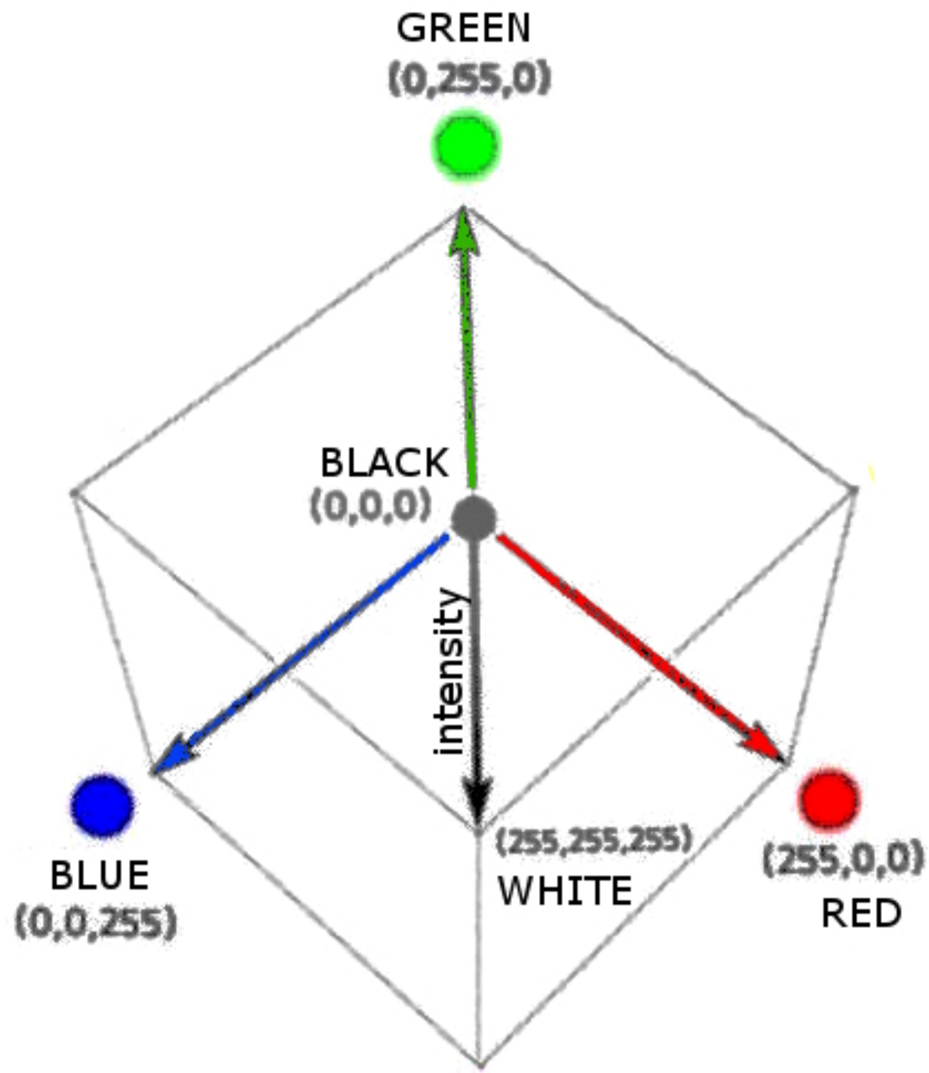
- General task in image analysis is detection whether two given segments represent the same object - shot from the same or different point of view. Mathematically, color image segment is a rectangular matrix with 3D vector elements.



GC: IMAGE COMPARING & RECOGNITION

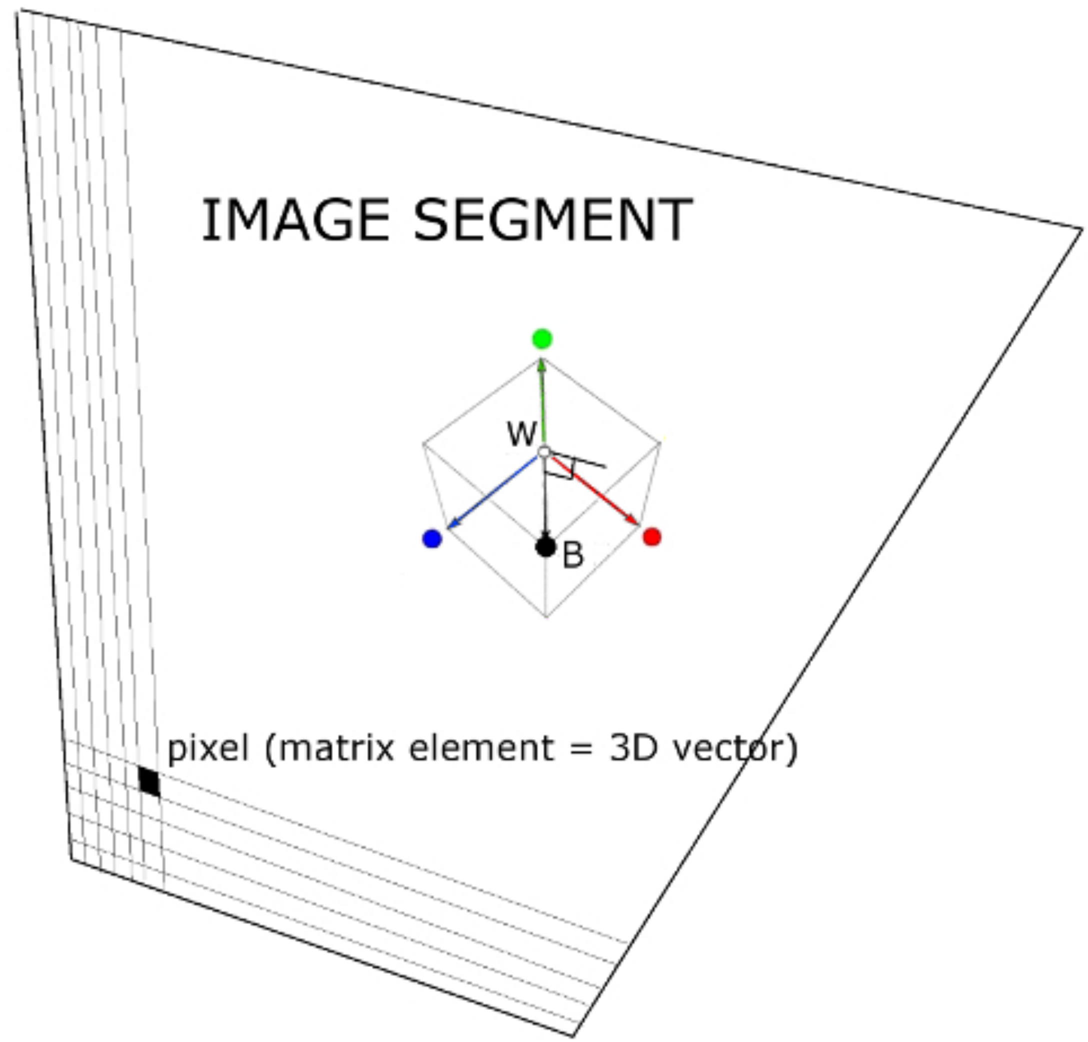
- **RGB model**

Each pixel of color image is represented as 3D vector in 3D cube. Vector length represents intensity, vector direction – color.



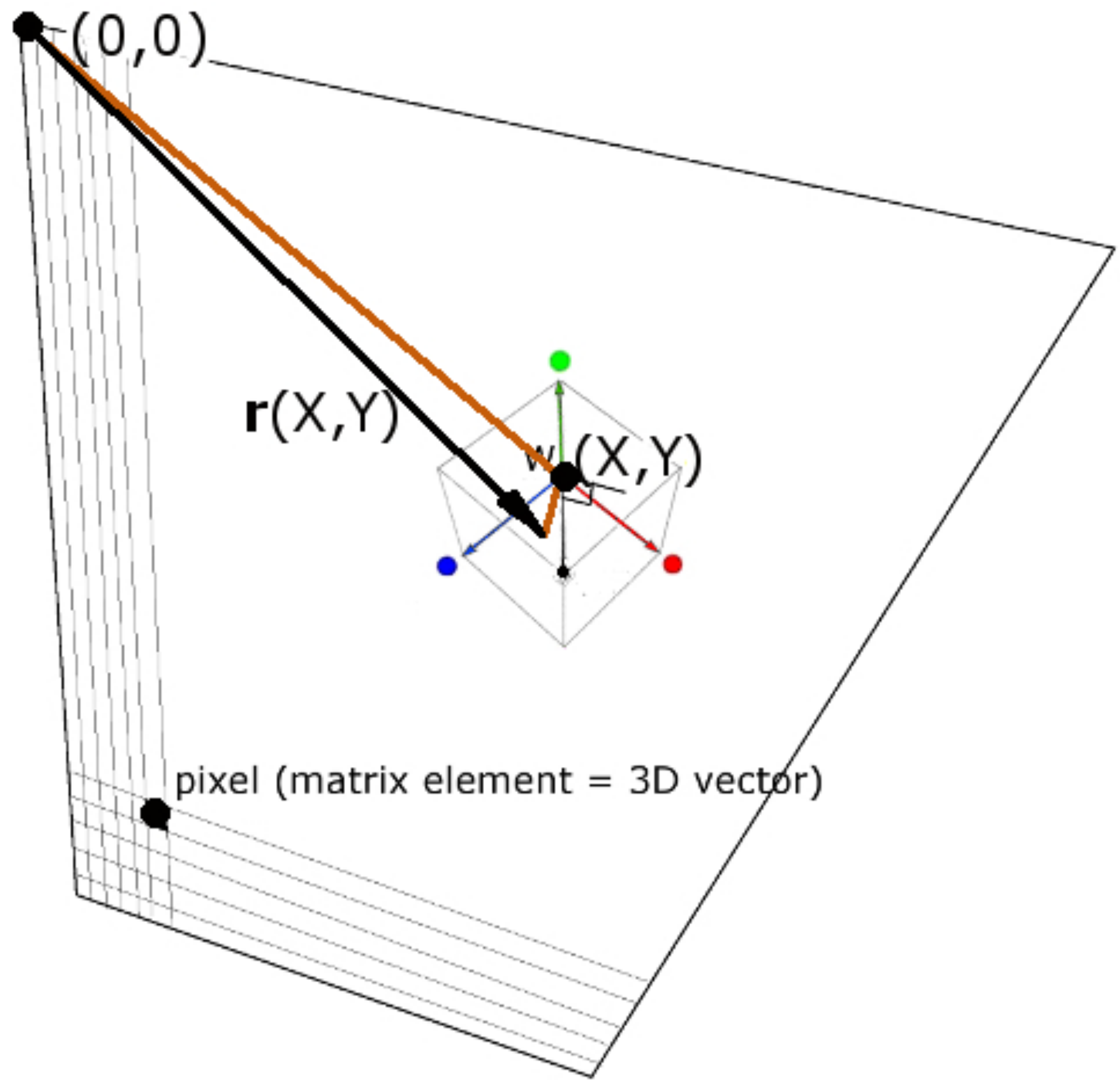
GC: IMAGE COMPARING & RECOGNITION

We use RGB space rotated in such way, that **Black** corner of RGB cube appear to be the highest point and **White** - the lowest. Such cube is placed in each pixel with main diagonal orthogonal to the image plane.



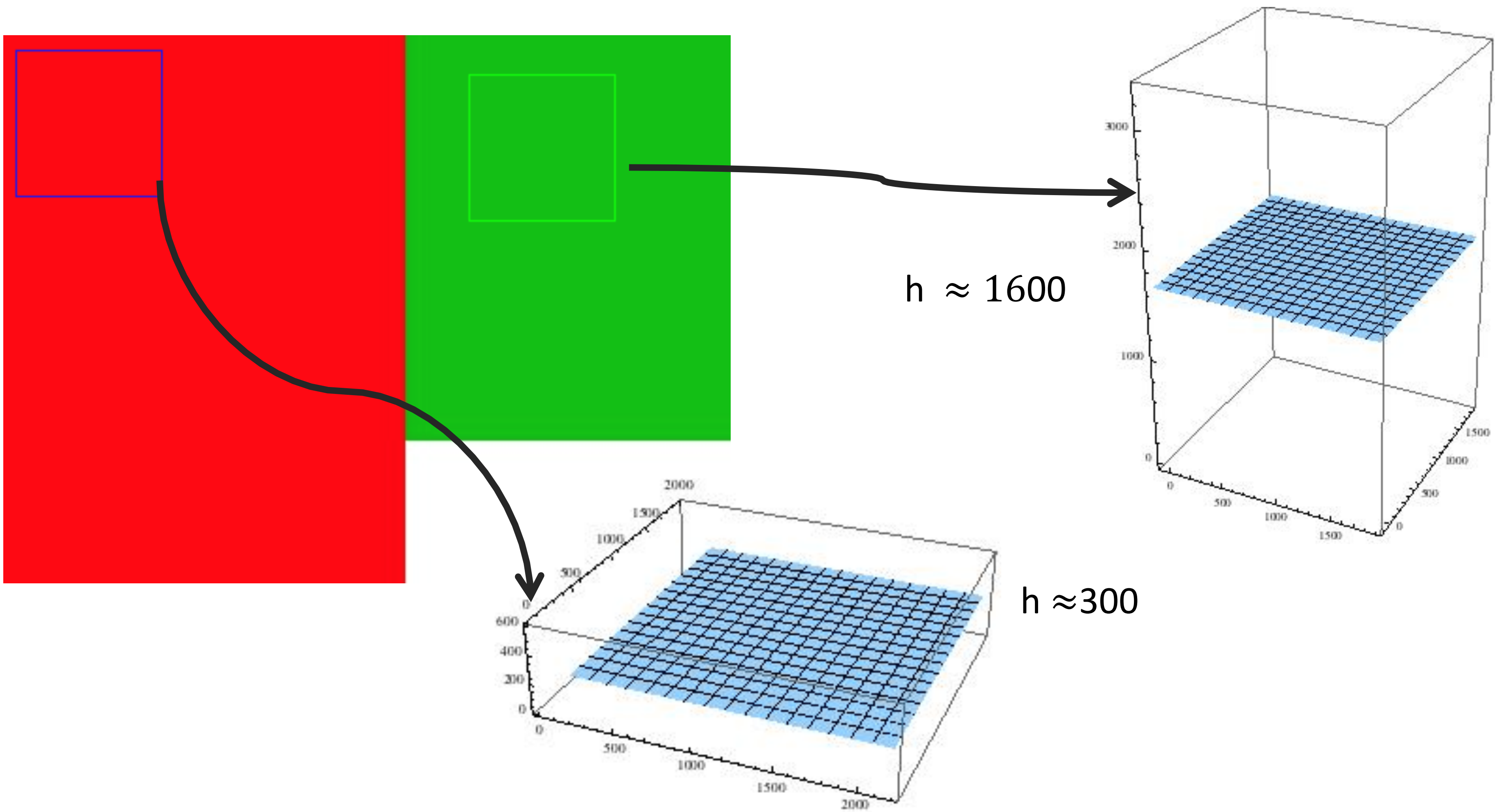
GC: IMAGE COMPARING & RECOGNITION

White lays on image plane itself, so surface for *purely white* image coincide with the image plane.

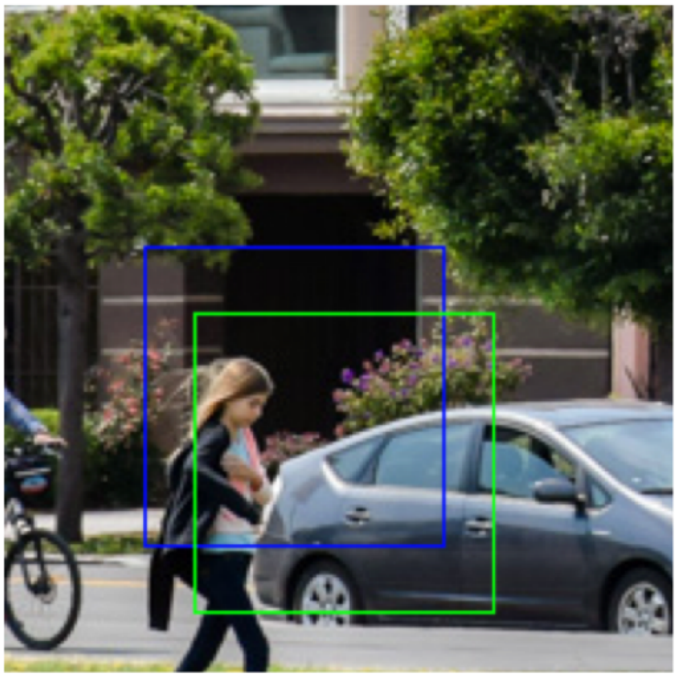


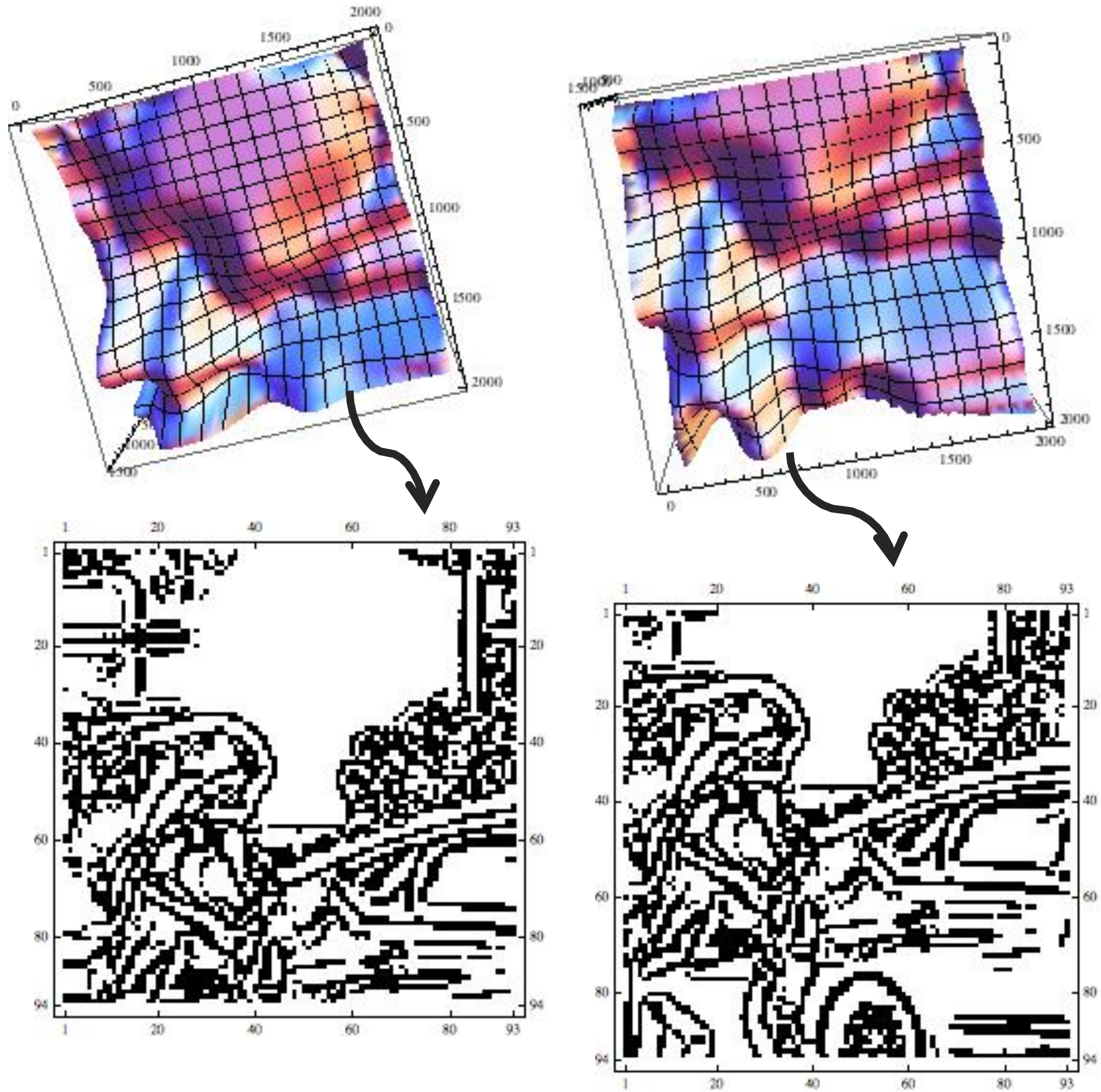
GC: IMAGE COMPARING & RECOGNITION

Coding surfaces for monocolor images(example)

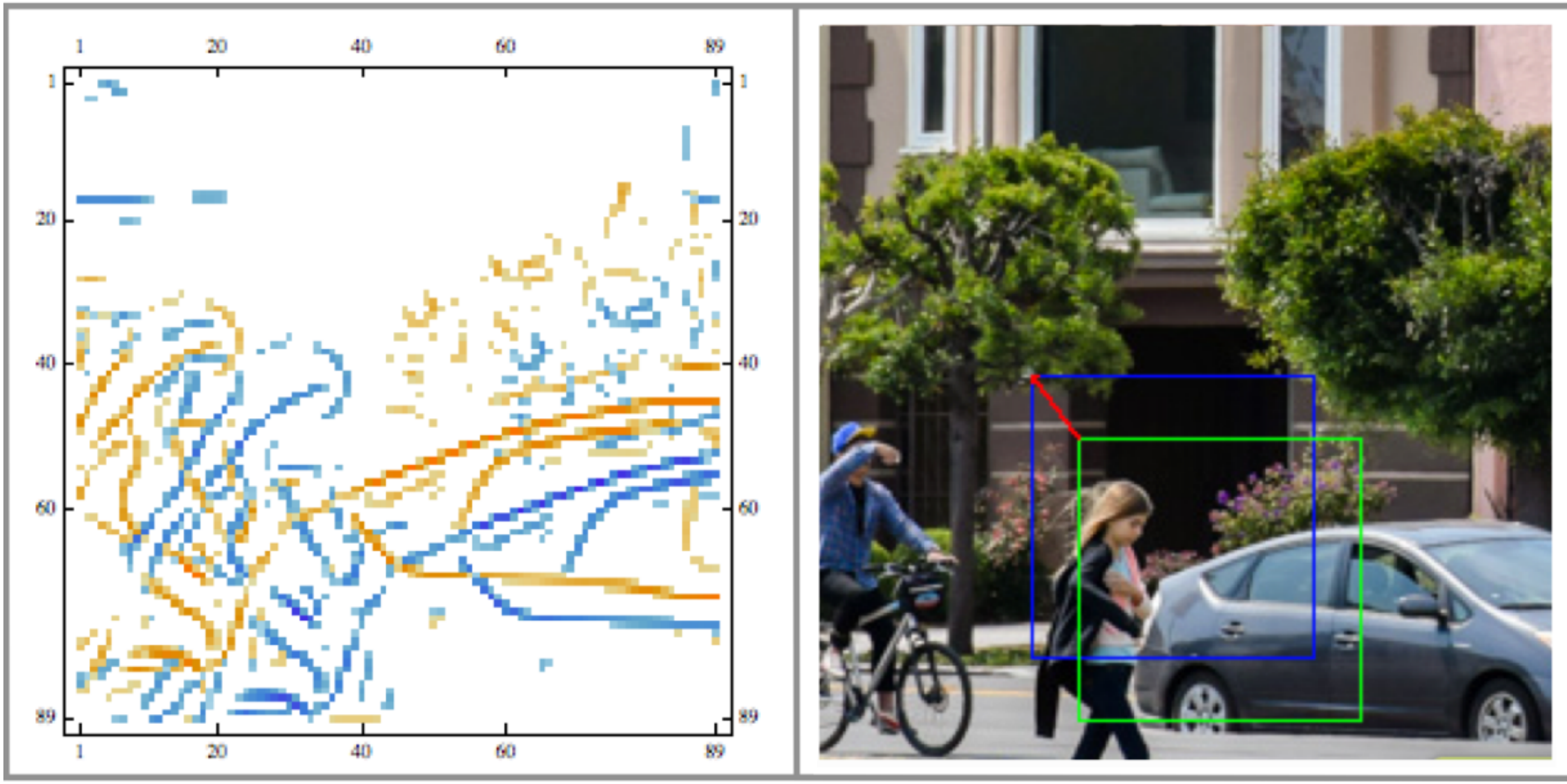


GC: IMAGE COMPARING & RECOGNITION

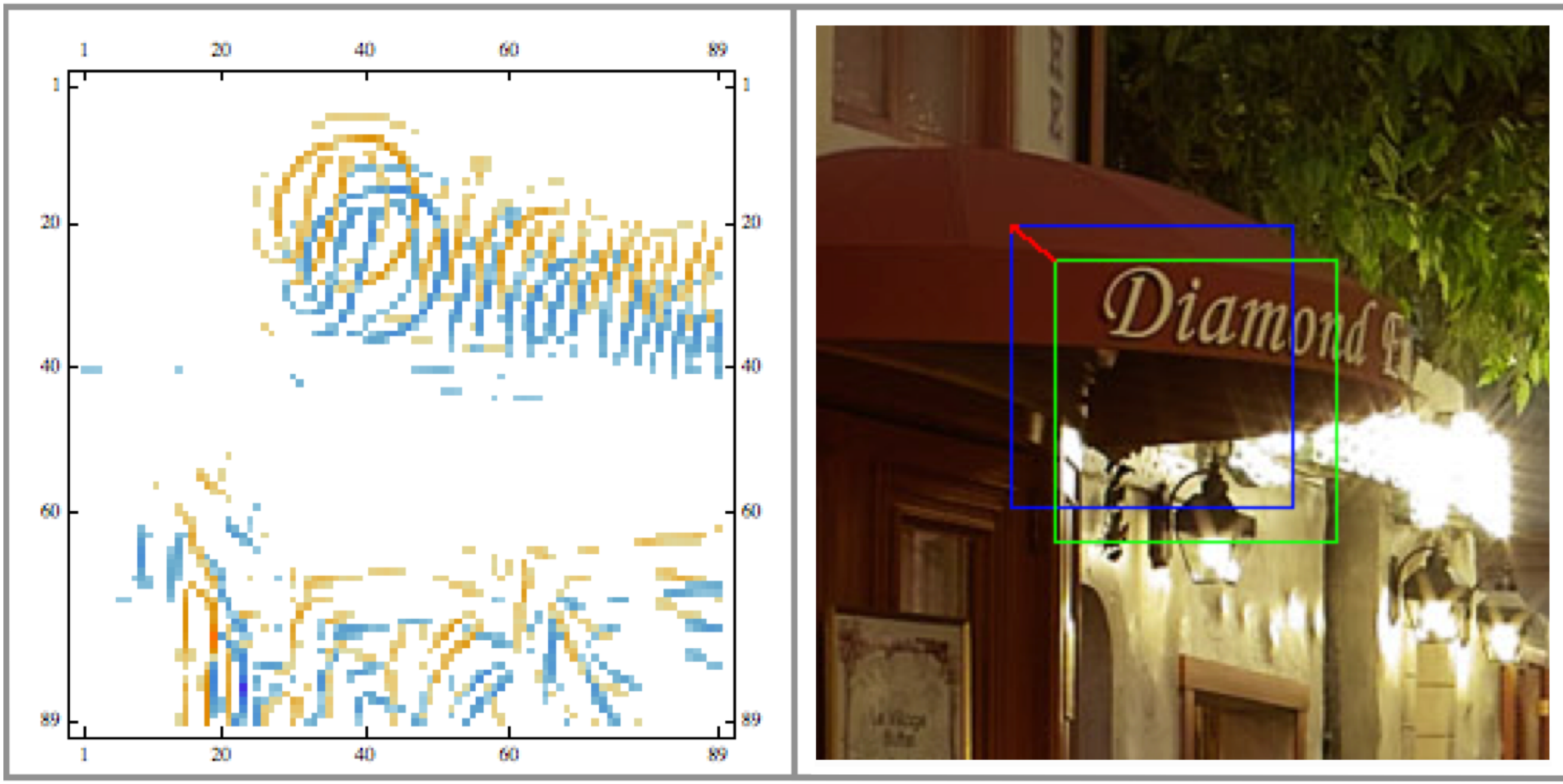


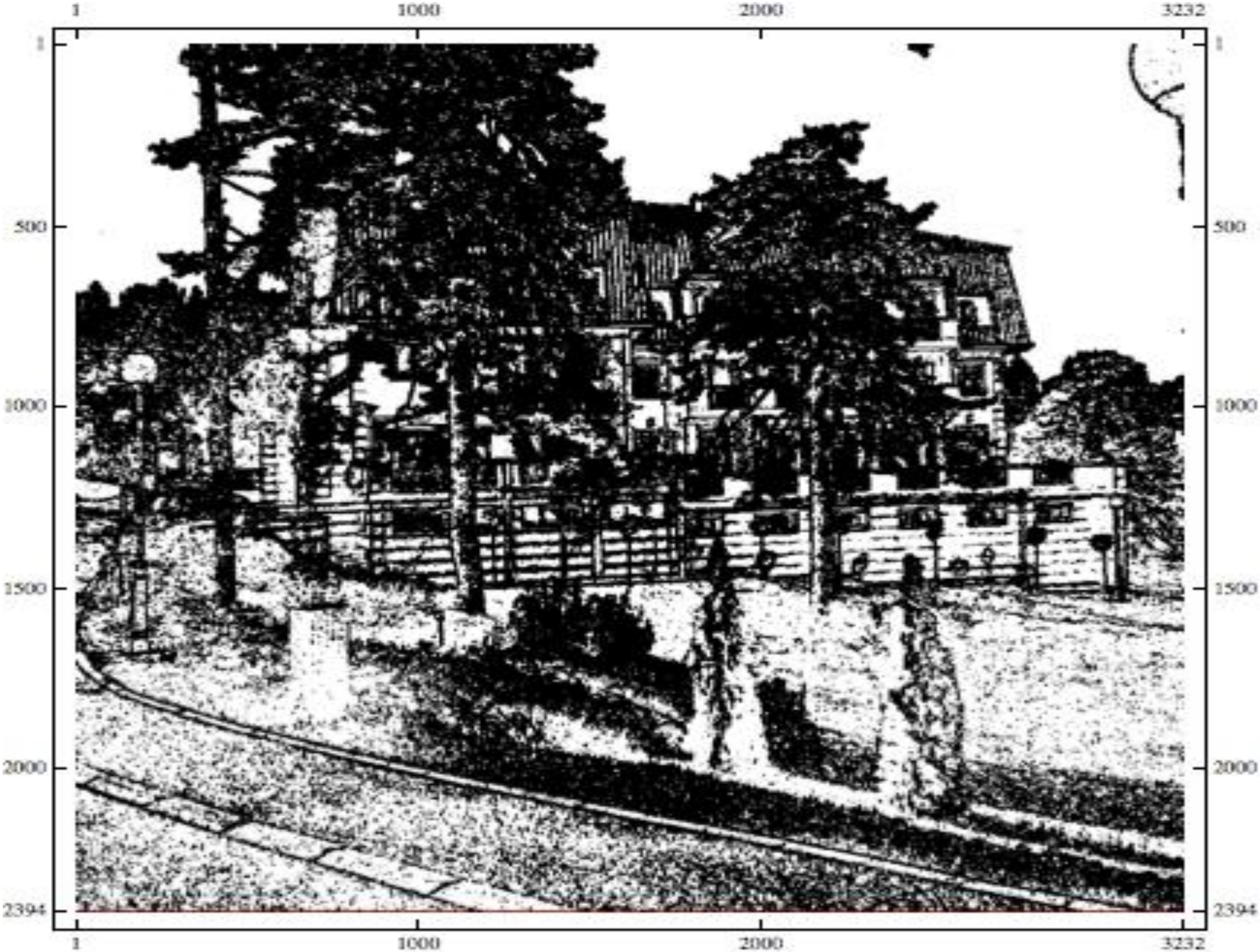


GC: IMAGE COMPARING & RECOGNITION



GC: IMAGE COMPARING & RECOGNITION

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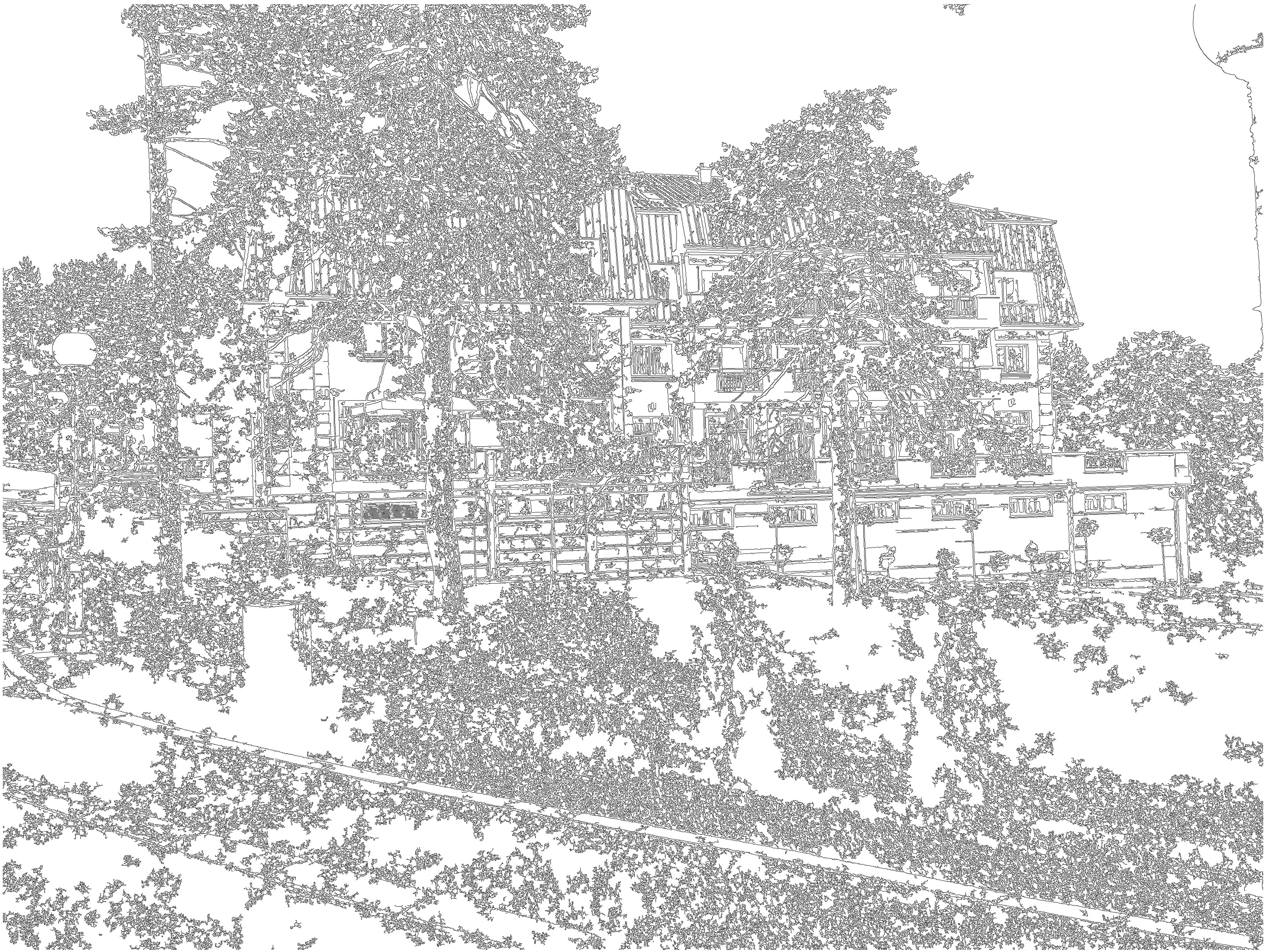


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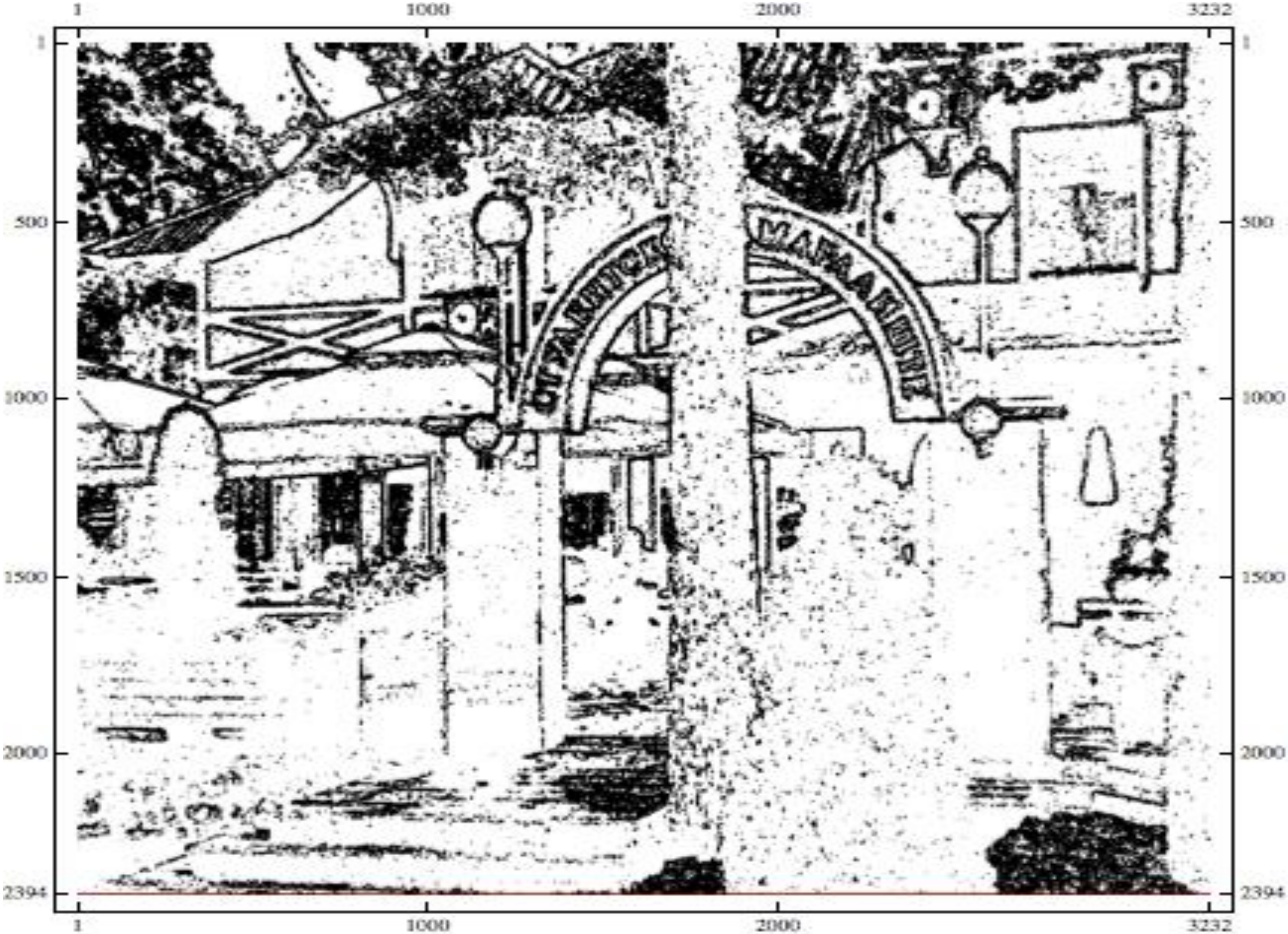
АМАРАЛИШТЕ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СТУДЕНТСК


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GC algorithm

Canny algorithm

CONCLUSIONS

Geometrical coding for digital images is new promising method which opens a way to analyze full-color images directly without converting them to monochrome ones. It has linear computational complexity with respect to image volume. It's resolution even in initial version is comparable with the resolution of best known today algorithms.

Thank you for your attention!