IBISA:
Image-Based Identification/Search for Archaeology

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http://dept-info.labri.fr/~sm/Projets/IBISA/

Introduction

IBISA (Image-Based Identification/Search for Archaeology)

- aims at **searching by example** in databases of archaeological objects
  - to identify the object (*e.g.* museum collections, stolen objects)
  - to find similar objects (*e.g.* same matrix, same style)
- images are easier to manipulate and to share. . .
- comparing these objects / images (up to a few thousands) is still time-consuming and exhausting, thus error-prone

$\Rightarrow$ computer vision techniques can help the user decide **semi-automatically**, especially when the objects look very similar at first sight for a non-specialist. . .

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Outline

1. **Archaeological Data**
   - Physical Objects
     - Ancient Coins
     - Medieval Tiles
   - Digital Images
2. **Identification and Search**
   - Segmentation
   - Registration
   - Similarity
3. **IBISA Software**

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Physical Objects

- quasi flat (two-dimensional)
- produced from matrices
  via some striking / stamping / casting process
- the original matrices are generally lost now
- but many objects with their prints can still be found
- these objects underwent some alteration
  (wear, patina, break. . .) over centuries
- they share many similarities (same matrix, same style, etc.)

$\Rightarrow$ semi-automatic study of this similarity among large finds, to guess

- the original fabrication process
- its chronology, geography
- economical or social issues

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Ancient Coins

Silver coin *(denarius)* of the Roman Republic.
[credits: Numismatica Ars Classica]

- coins with the same die(s)
- obverse / reverse die combination

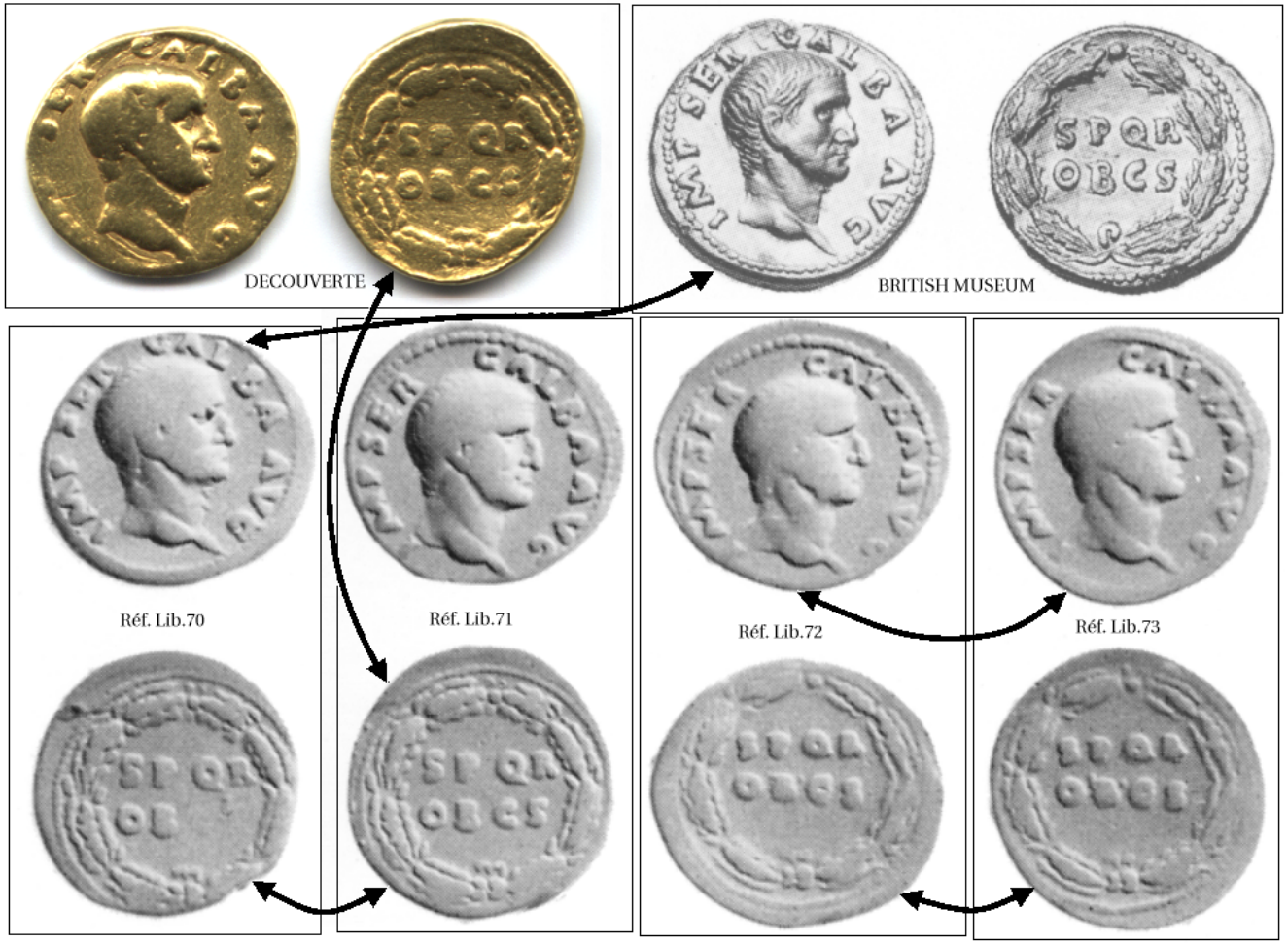
⇒ chronology of the strike,

organization of the mint. . .

[credits: Museum of London]

The seated man uses tongs to hold the **punch die** over the **anvil die**, with the metal flan between them. The standing man strikes the ensemble with a hammer.

Study of Coin Hoards



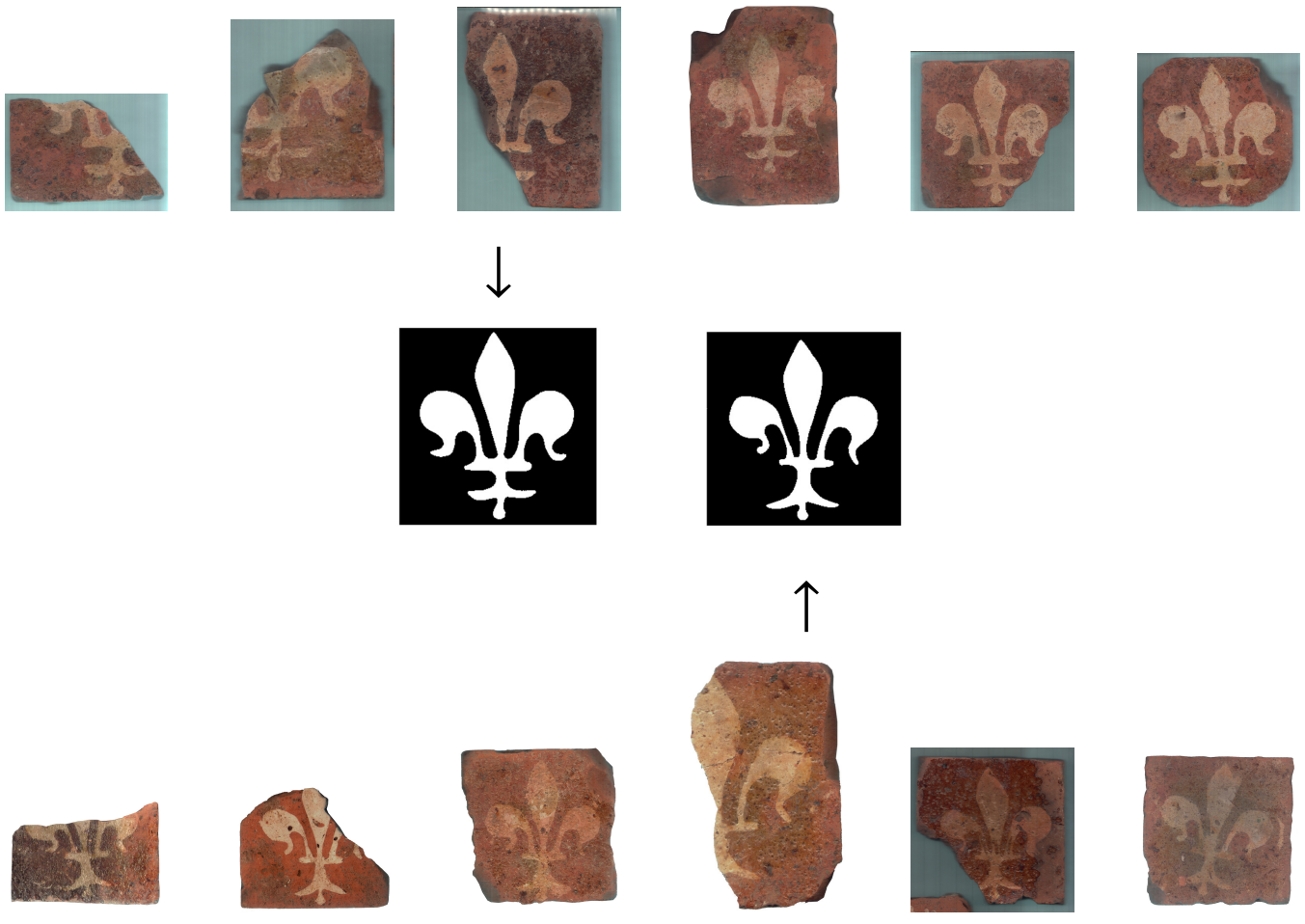
Medieval Tiles

Medieval glazed earthenware tiles from the castle of Villandraut (France, 14th century).

A design was carved on some wooden **pattern block**,

used in turn to stamp the earthernware tiles.

Study of Tile Pavements



Digital Images

images are much easier to manipulate and to share...

$g(p)$: (gray-scale) value of the image g at the point p

- photograph or scan of the objects or existing pictures (books)
- often lacks the chromaticity information (coin patina, B&W books, etc.)
- may suffer form Moiré problems (books)

→ our system manipulates gray-scale images in the spectral domain

(and imports common file formats such as JPEG, TIFF, etc.)

How to get rid of the (other) viewing conditions?

Rigid Transformations

centering, alignment, scaling problems: very likely to occur in photographs
$\Rightarrow$ resistance to rigid transformations (translation, rotation and homothety)

$$p' = (p + t) \cdot r \quad \text{with} \quad t = \underbrace{\Delta_x + i\Delta_y}_{\text{translation}} \quad \text{and} \quad r = \underbrace{s}_{\text{homothety}} \cdot \underbrace{e^{i\phi}}_{\text{rotation}}$$

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Cartesian vs log-polar coordinates

rotation+homothety of angle ϕ and ratio $s \rightarrow_{\log}$ **translation** of vector $(\log(s), \phi)$

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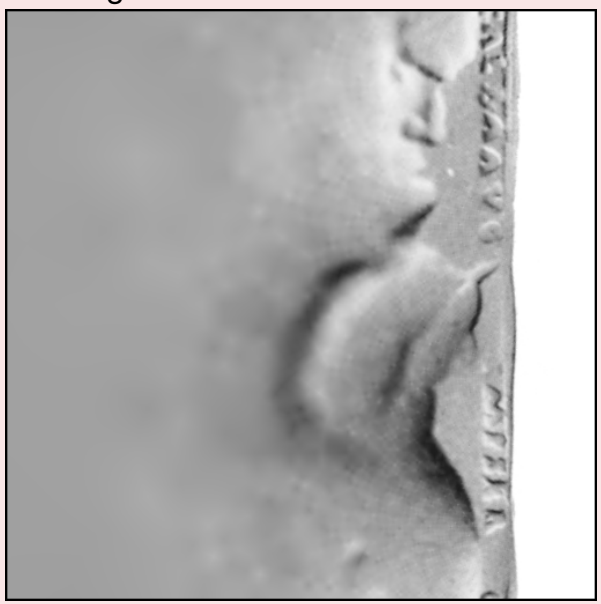

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Segmentation

first get rid of the background context, that would interfere with registration, using active contours *(snakes)*

- starting from an initial shape
- deformed in the image until it matches the outlines of the object
- using an energy minimizing process

$$E_{\text{total}}(C) = E_{\text{internal}}(C) + E_{\text{external}}(C)$$

$$E_{\text{internal}}(C) = \int_a^b \left(\alpha \underbrace{\left|\frac{\partial p}{\partial s}\right|^2}_{\text{length}} + \beta \underbrace{\left|\frac{\partial^2 p}{\partial s^2}\right|^2}_{\text{curvature}} \right) ds$$

$$E_{\text{external}}(C) = \int_a^b \underbrace{-\left|\nabla g(p(s))\right|^2}_{\text{gradient}} ds$$

Registration

find the optimal superposition of the two images $g(p)$ and $g' = g(p')$

$$p' = (p + t) \cdot r \quad \text{with} \quad t = \underbrace{\Delta_x + i\Delta_y}_{\text{translation}} \quad \text{and} \quad r = \underbrace{s}_{\text{homothety}} \cdot \underbrace{e^{i\phi}}_{\text{rotation}}$$

Registration algorithm:

1. find the rotation+homothety r (estimate (ϕ, s))
   - by finding a translation in the log-polar system,
   - by considering the amplitude spectra of the images (to ignore the effects of the translation t);
2. invert the rotation+homothety (rotation of angle $-\phi$ and homothety of ratio $1/s$);
3. find the translation t (estimate (Δ_x, Δ_y)), now free from any rotation or homothety;
4. invert the translation (translation of vector $(-\Delta_x, -\Delta_y)$).

Similarity

After registration, the classic inter-correlation factor

$$F(g_1, g_2) = \frac{\sigma_{12}}{\sigma_1 \sigma_2} = \frac{\sum_P \left(g_1(p) - \overline{g_1}\right) \cdot \left(g_2(p) - \overline{g_2}\right)}{\sqrt{\left(\sum_P \left(g_1(p) - \overline{g_1}\right)^2\right) \cdot \left(\sum_P \left(g_2(p) - \overline{g_2}\right)^2\right)}}$$

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yields very good results in practice...

Preliminary Results

image T	image 1	image 2	image 3
			
100%	97%	72%	64%

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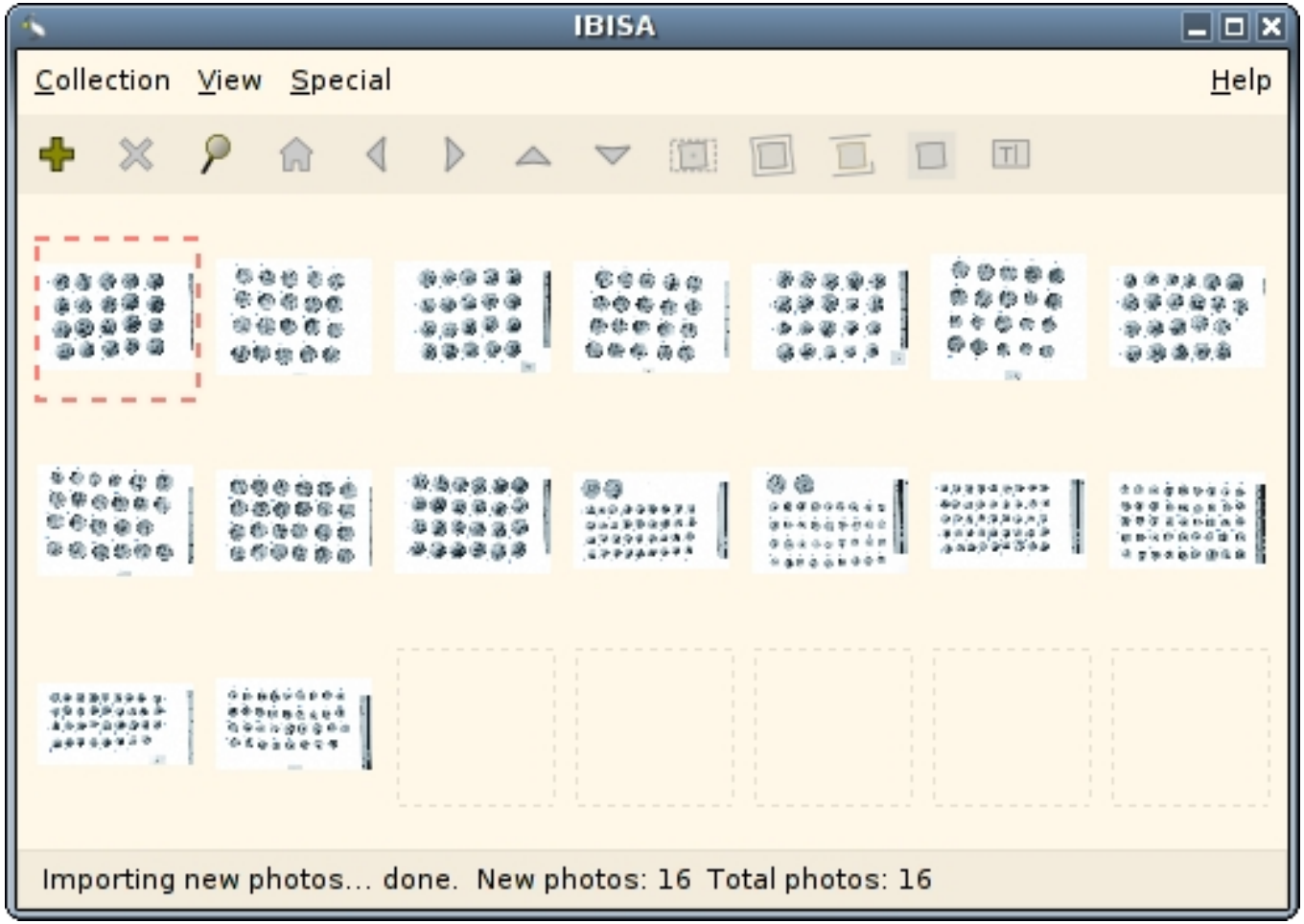
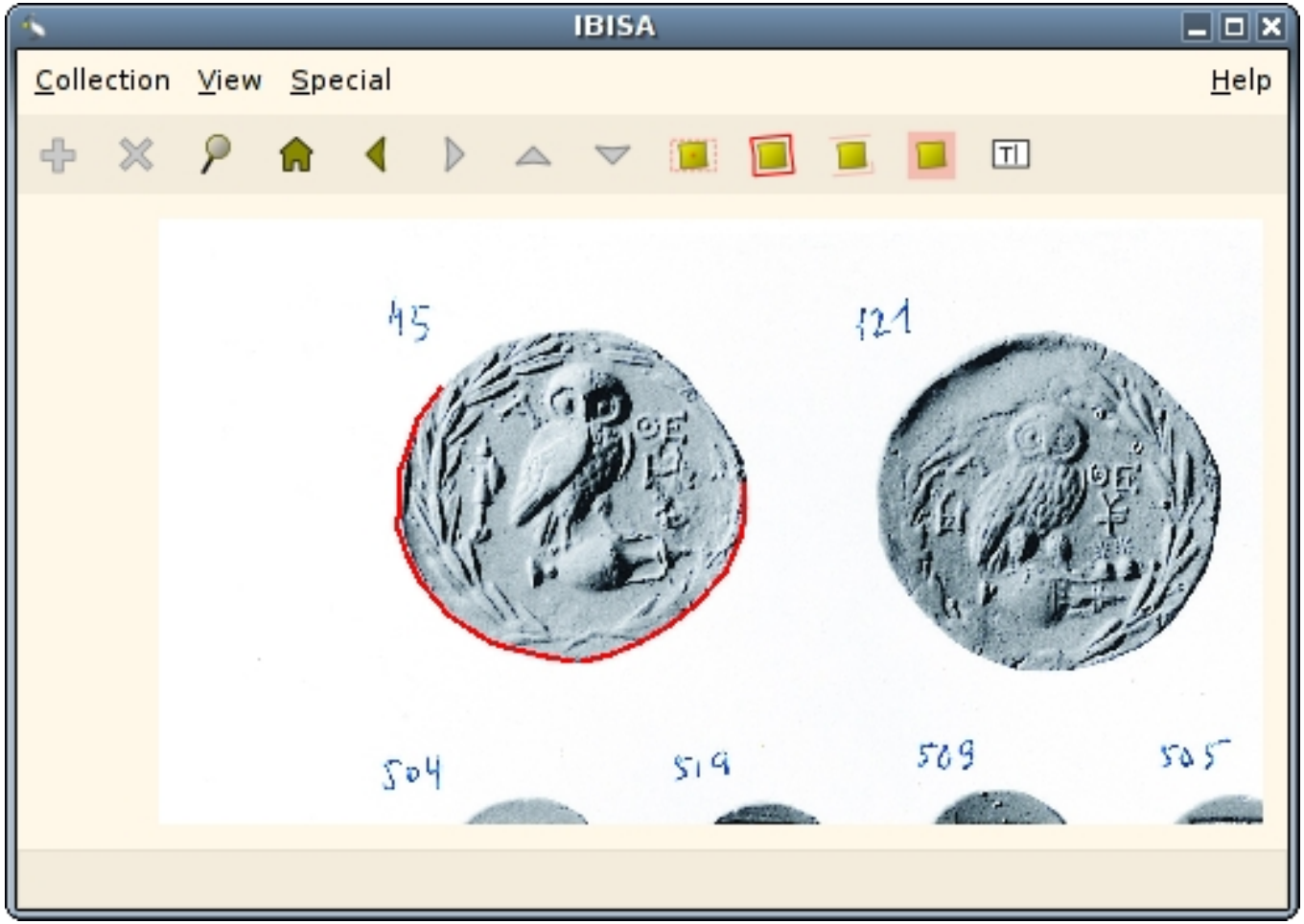


importing pictures of ancient Greek coins

IBISA Software



segmentation of a coin (in manual mode)

IBISA Software

segmentation of a coin (in automatic mode)

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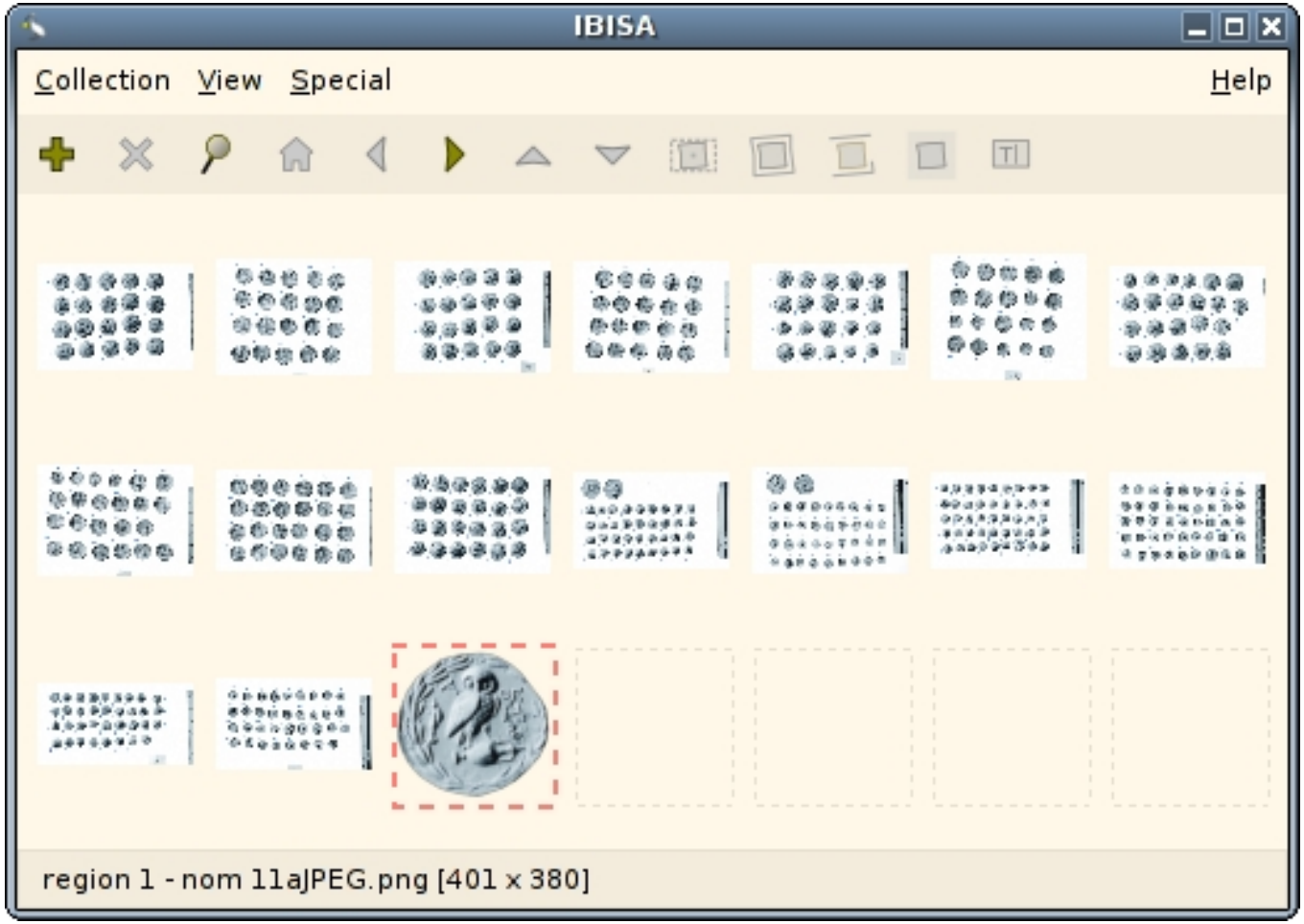
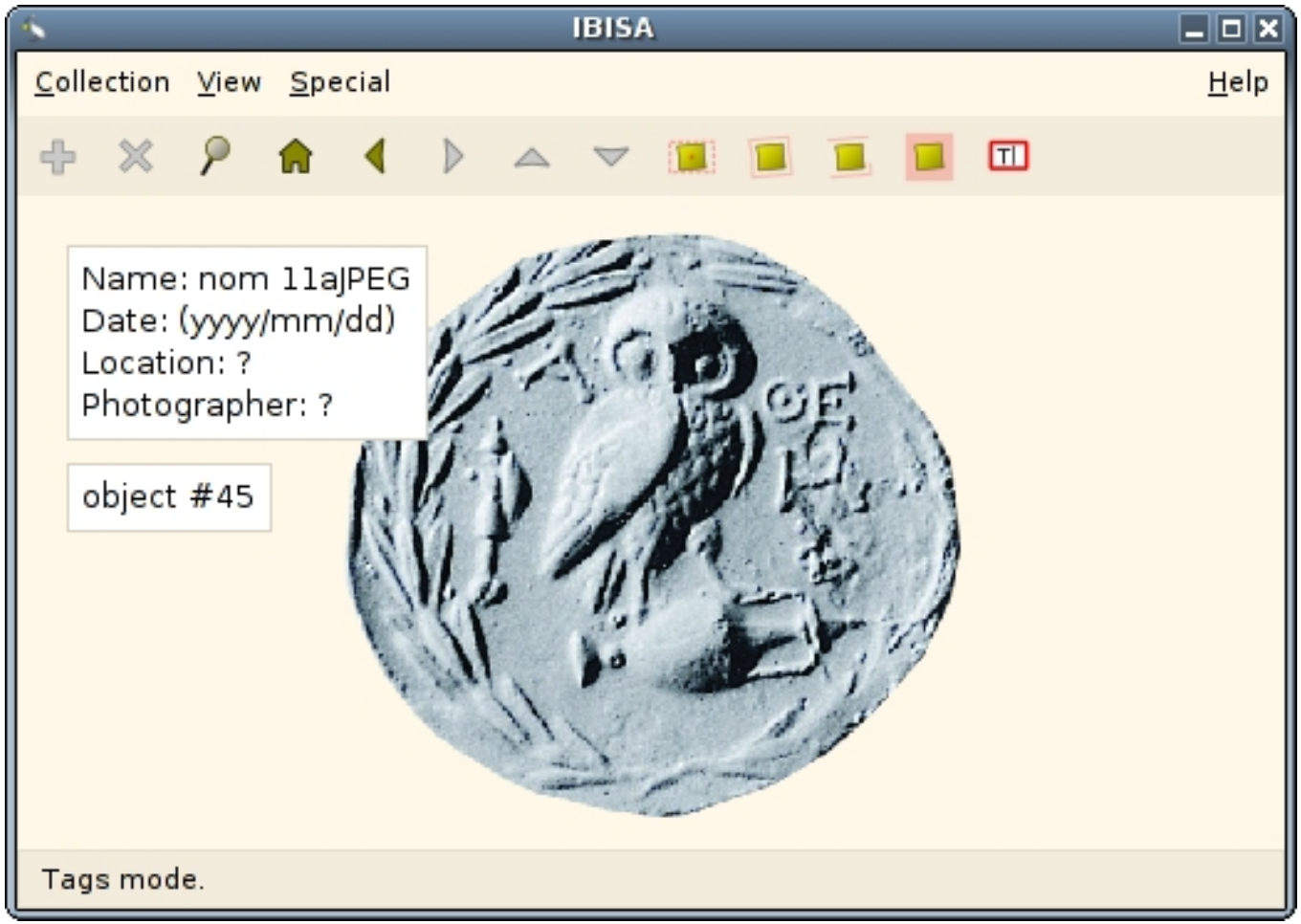


selecting the new picture

IBISA Software



adding tags

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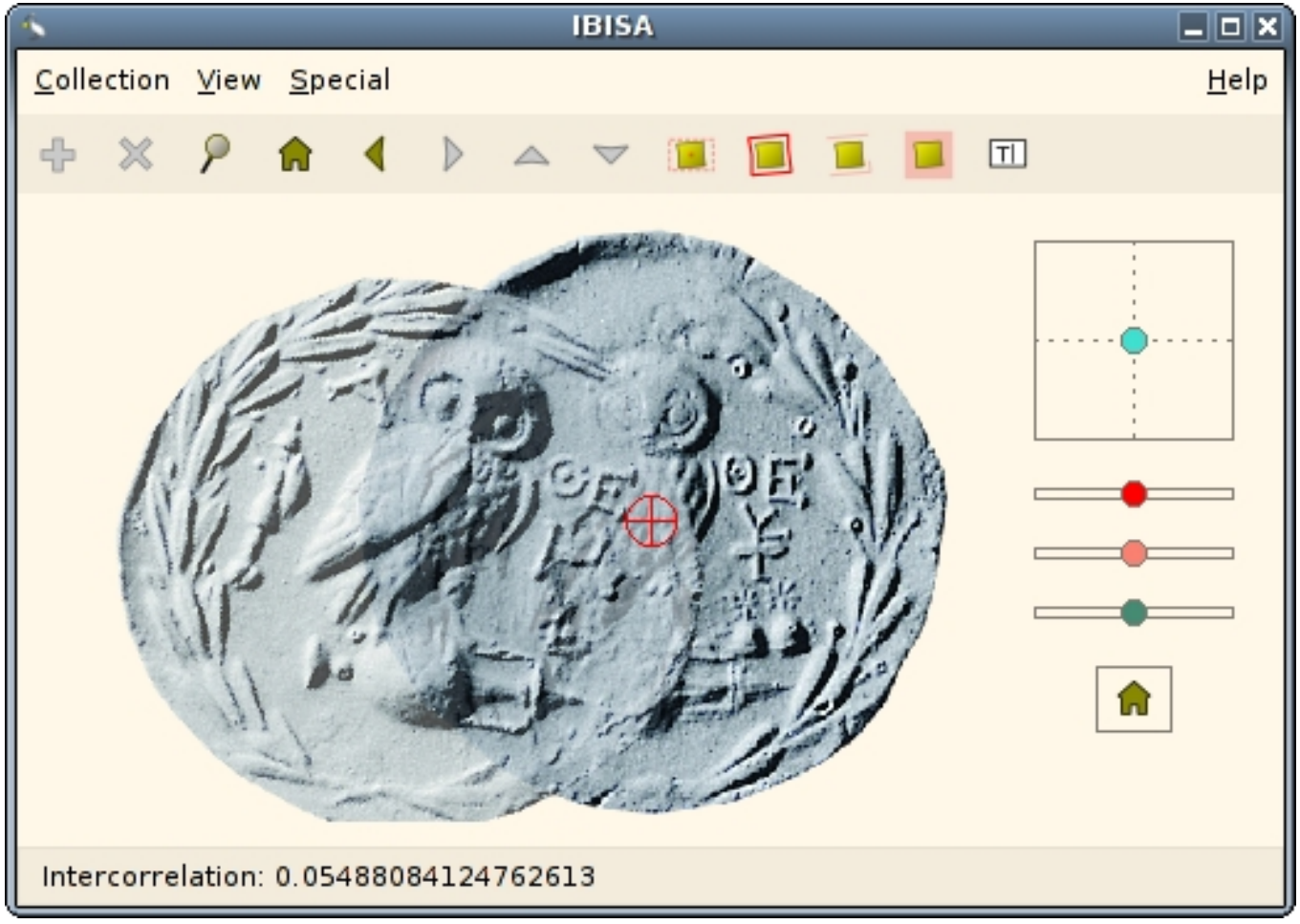

registration (in manual mode)

IBISA Software

registration (in automatic mode)

Conclusions and Perspectives

IBISA (Image-Based Identification/Search for Archaeology):

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  - ancient coins ⇒ **study of ancient coin hoards**
  - medieval tiles
- **allows the user to search by example**
- **discovers similarities (same matrix, same style, etc.)**
- taking advantage of robust computer vision techniques
- need for an enhanced segmentation method (medieval tiles)
- need for handling fragments of objects (medieval tiles)
- system to be validated on real (large) databases
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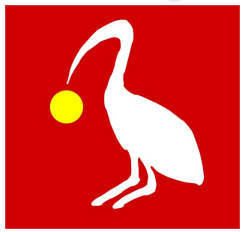

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