From Signal to Meaning

Digitally facilitating perception and interpretation(s) of ancient texts

Ségolène Tarte
Oxford e-Research Centre, University of Oxford

E-Research on Texts and Images
Colloquium
11-12 May 2010, British Academy, London

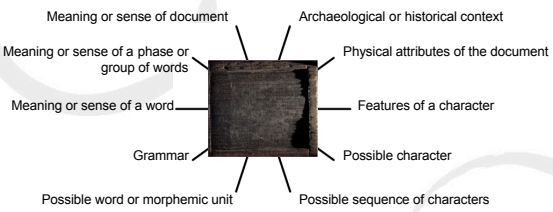
Oxford University
Centre for the Study of Ancient Documents
UCL Department of Information Studies

oerc
Oxford e-Research Centre

E-Science and Ancient Documents project

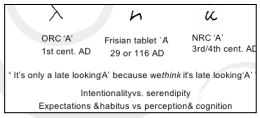
- Targeted documents:
  - Stone
  - Lead
  - Wood
- Aim: develop a web-based Interpretation Support System (ISS) for ancient and damaged documents:
  - Image processing (image enhancement, feature detection, web-services)
  - Recording tool capturing the chain of evidence and reasoning enabling to reconstruct the hermeneutic process (argumentation theory and epistemology)
  - Access external knowledge bases, e.g. linguistics, palaeographical, archaeological (contextual encoding, web-services)

Model of papyrological reading



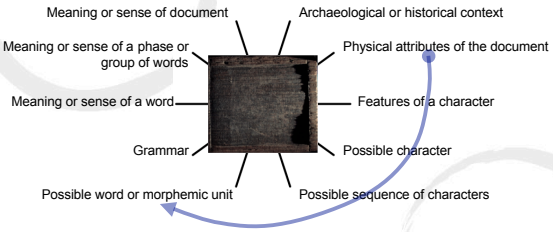
[Terras 2006, inspired by Rumelhart and McClelland 1986]

What experts do: oscillations, perception and interpretation

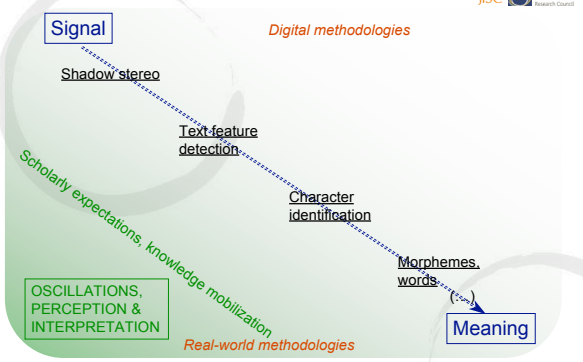


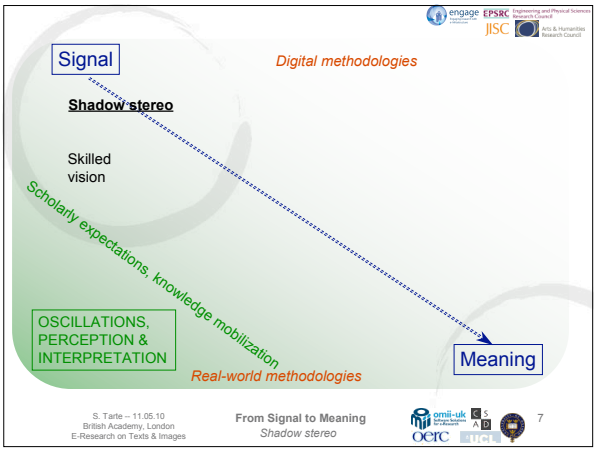
- Experts' strategies :
  - **Tracing - Kinaesthetics**
    - Visual feedbak loop between mental/drawn image of the text and text
    - Embodiment of the script
  - **Puzzling - Cruciverbalistic**
    - Intutitve knowledge of language (e.g., occurences of letters)
    - Puzzle solving, semiotics
- Key **implicit processes** that hold a crucial role in the development of hypotheses of interpretations (**percepts**):
  - Mutability of (un)certainty
  - Expectations of expertise
    - Visual, palaeographical, linguistic, historical
- Leading to:
  - Tensions in the form of **contradictions**
  - Corroborations in the form of **mutual support**
  - Commitment to / rejection of a given interpretation

Model of papyrological reading



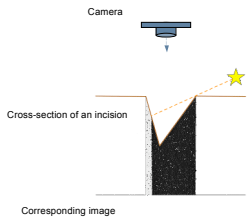
[Terras 2006, inspired by Rumelhart and McClelland 1986]



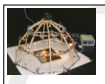


Shadow stereo principle

- Capturing volumetric information with digital photographs:
  - The highlight and shadow areas move according to the position of the light
  - Stains stay in place



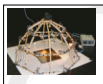
→ Mimics experts' tablet rocking in raking light!
Digitisation is already part of the interpretation process

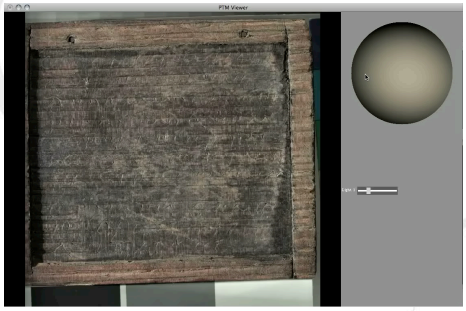


Frisian tablet. Original transcription by C.W. Vollgraff, *1917 -- "De tabella emptionis aetatis Traiani nuper in Frisia reperta"*

New transcription by A.K. Bowman, R.S.O. Tomlin, and K.A. Worp, *2009 JRS -- "Emptio bovis Frisica: the 'Frisian ox sale' reconsidered"*

→ Digital pictures by Dr. C. Crowther





Polynomial Texture Mapping a PTM image of the same tablet

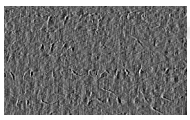
Background correction algorithms

Original greyscale image

- Illumination correction, by homomorphic filtering
- Wood-grain removal, by Lambertian compensation

Implemented in Matlab, run on the NGS as a web-service within VRE

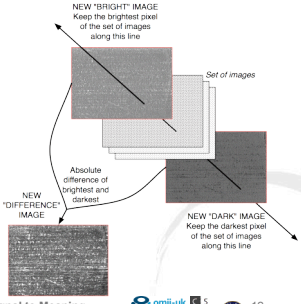
After illumination correction

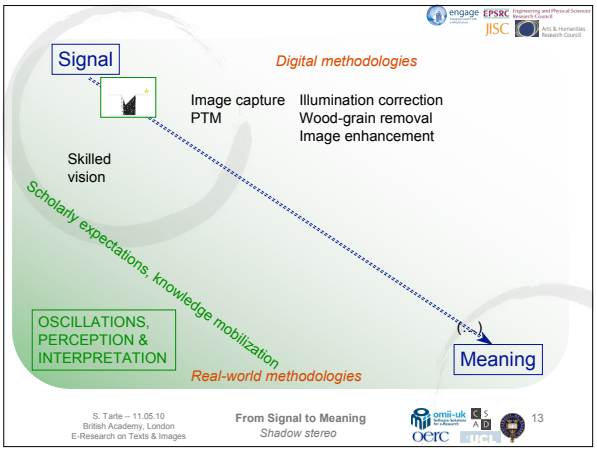


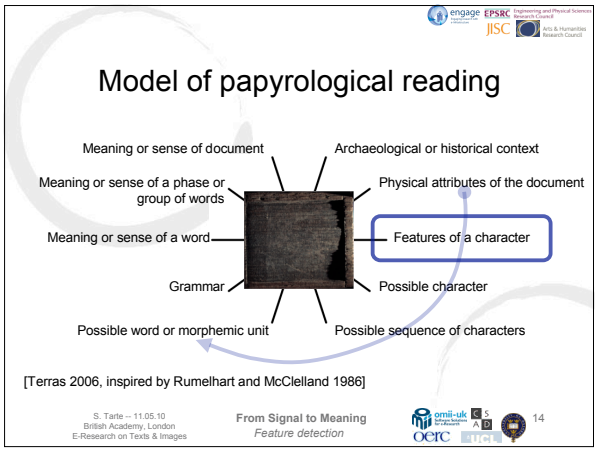
After wood-grain removal

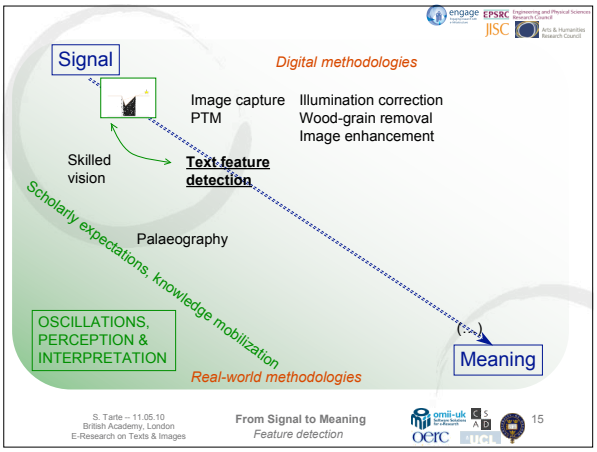
Image enhancement

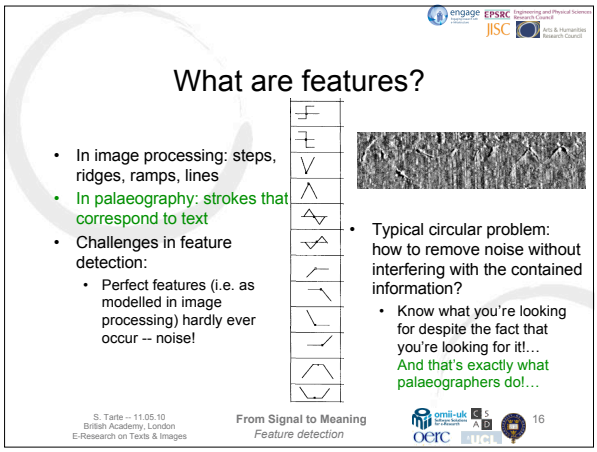
- Combine images for interesting lighting positions (lighting directions approx aligned with wood-grain)
  - After image enhancement (illumination correction and wood-grain removal):
  - Noise and stains have similar brightness from one image to the next
  - Shadows and highlights of the incisions move according to the light position

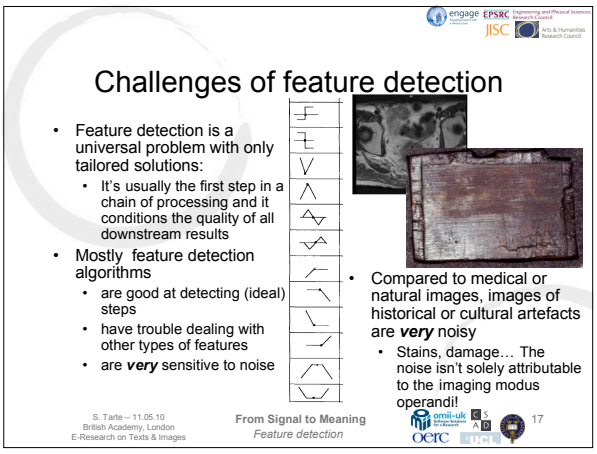


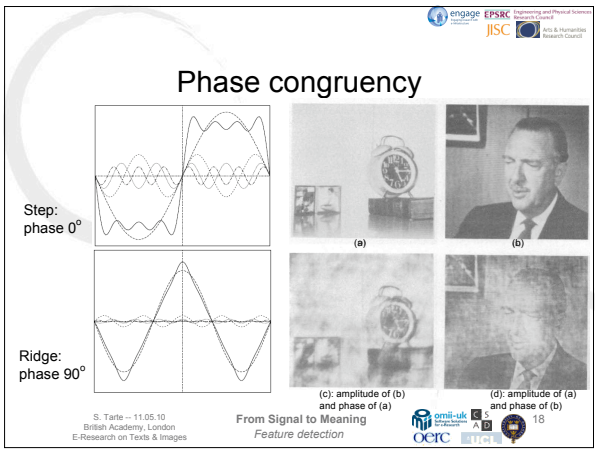

Signal
Digital methodologies
Image capture
PTM
Illumination correction
Wood-grain removal
Image enhancement
Skilled vision
Scholarly expectations, knowledge mobilization
OSCILLATIONS, PERCEPTION & INTERPRETATION
Meaning
Real-world methodologies
S. Tarte -- 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Shadow stereo
13


Model of papyrological reading
Meaning or sense of document
Archaeological or historical context
Meaning or sense of a phase or group of words
Physical attributes of the document
Meaning or sense of a word
Features of a character
Grammar
Possible character
Possible word or morphemic unit
Possible sequence of characters
[Terras 2006, inspired by Rumelhart and McClelland 1986]
S. Tarte -- 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Feature detection
14

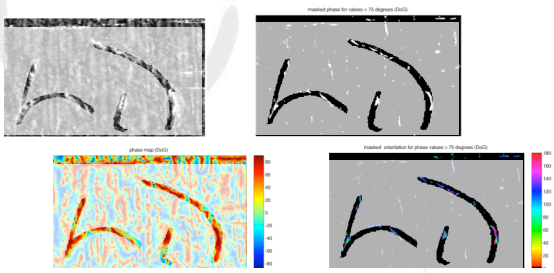

Signal
Digital methodologies
Image capture
PTM
Illumination correction
Wood-grain removal
Image enhancement
Skilled vision
Text feature detection
Palaeography
Scholarly expectations, knowledge mobilization
OSCILLATIONS, PERCEPTION & INTERPRETATION
Meaning
Real-world methodologies
S. Tarte -- 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Feature detection
15


What are features?
In image processing: steps, ridges, ramps, lines
In palaeography: strokes that correspond to text
Challenges in feature detection:
Perfect features (i.e. as modelled in image processing) hardly ever occur -- noise!
Typical circular problem: how to remove noise without interfering with the contained information?
Know what you're looking for despite the fact that you're looking for it!…
And that's exactly what palaeographers do!…
S. Tarte -- 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Feature detection
16


Challenges of feature detection
Feature detection is a universal problem with only tailored solutions:
It's usually the first step in a chain of processing and it conditions the quality of all downstream results
Mostly feature detection algorithms
are good at detecting (ideal) steps
have trouble dealing with other types of features
are very sensitive to noise
Compared to medical or natural images, images of historical or cultural artefacts are very noisy
Stains, damage… The noise isn't solely attributable to the imaging modus operandi!
S. Tarte -- 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Feature detection
17


Phase congruency
Step: phase 0°
Ridge: phase 90°
(a)
(b)
(c): amplitude of (b) and phase of (a)
(d): amplitude of (a) and phase of (b)
S. Tarte -- 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Feature detection
18

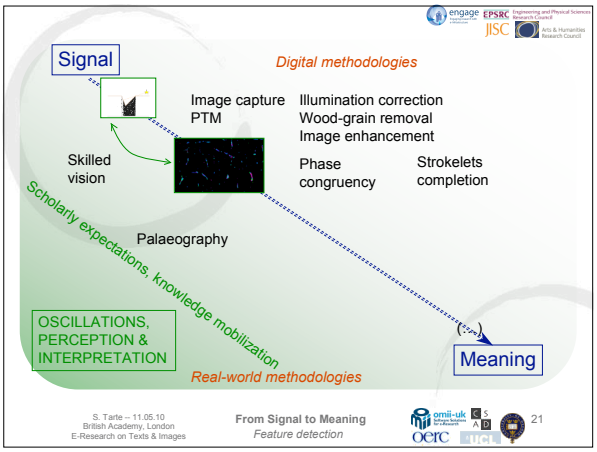
State-of-the-art monogenic signal based phase congruency

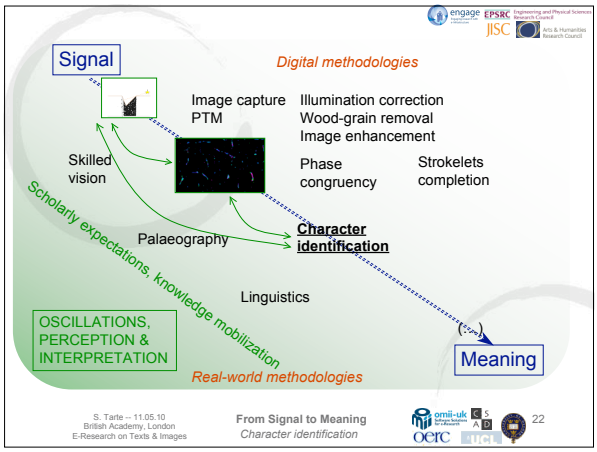


Strokelets completion

- Given character features, how to link them up to identify possible characters?
  - Subjective/illusory contours, Kanizsa triangles
    - (Use luminance and contrast)
    - Use geometric constraints

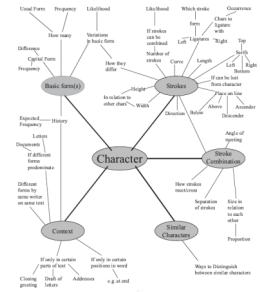
[Ullman 1976, Rutkowski 1979]



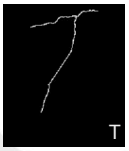


Letter shape ontology

- Qualitative shape characterisation of a letter based on constitutive strokes



[Terras 2006]



entity

Has-strokes

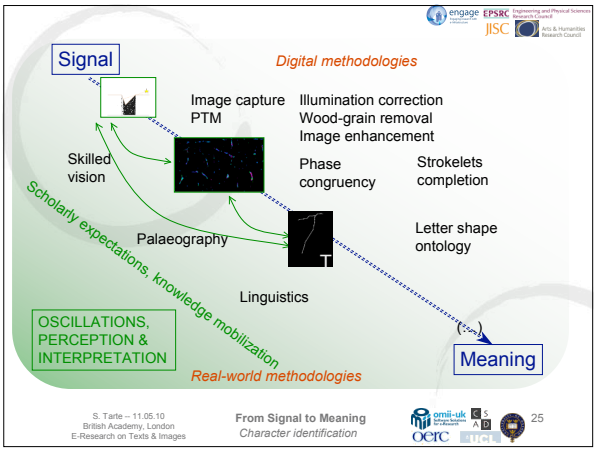
Has-junction:
u end-middle v
Angle ~90°

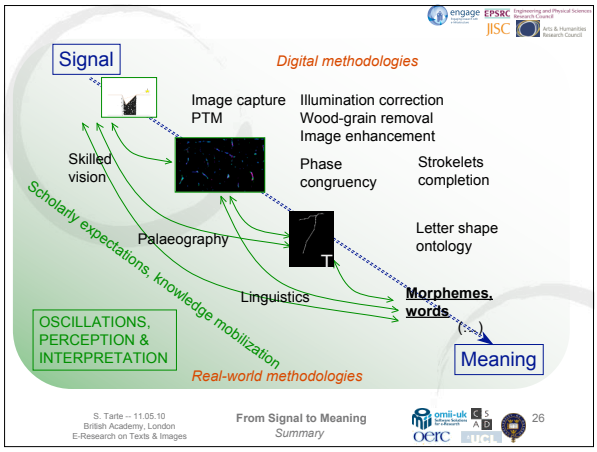
u,v

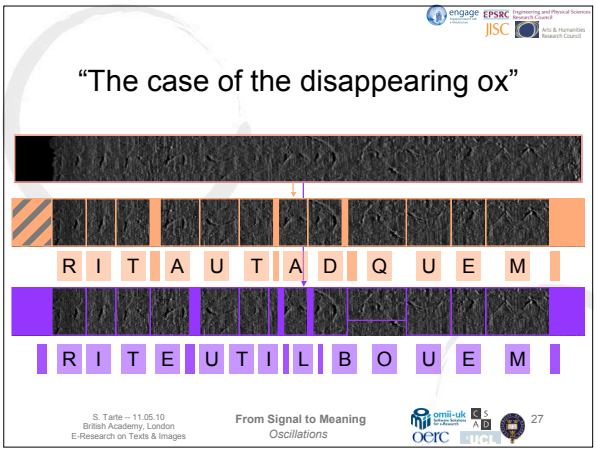
Orientation: {vertical, forward diagonal}
Below: v

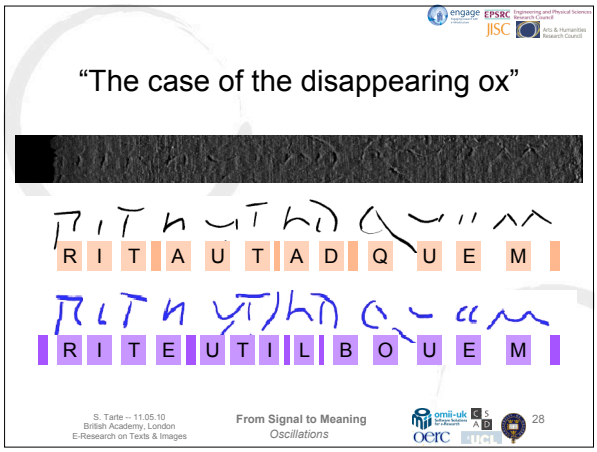
Orientation: horizontal
Above: u

Which corresponds to the qualitative description of a 'T'


Signal
Digital methodologies
Image capture
PTM
Illumination correction
Wood-grain removal
Image enhancement
Skilled vision
Phase congruency
Strokelets completion
Letter shape ontology
Palaeography
Linguistics
Scholarly expectations, knowledge mobilization
OSCILLATIONS, PERCEPTION & INTERPRETATION
Meaning
Real-world methodologies
S. Tarte – 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Character identification
25


Signal
Digital methodologies
Image capture
PTM
Illumination correction
Wood-grain removal
Image enhancement
Skilled vision
Phase congruency
Strokelets completion
Letter shape ontology
Palaeography
Linguistics
Morphemes, words
Scholarly expectations, knowledge mobilization
OSCILLATIONS, PERCEPTION & INTERPRETATION
Meaning
Real-world methodologies
S. Tarte – 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Summary
26


"The case of the disappearing ox"
R I T A U T A D Q U E M
R I T E U T I L B O U E M
S. Tarte – 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Oscillations
27


"The case of the disappearing ox"
R I T A U T A D Q U E M
R I T E U T I L B O U E M
S. Tarte – 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Oscillations
28

Characters
Contradiction
Mutual support
Mutability
Words
Document
Palaeography
Perception
Linguistics
Engineers
Interpretation
Papyrologists
Features
Phrases
Explicit
Implicit
Etsuko Ichikawa: Kokoro InBetween, 2008.
Glass pyrograph on paper. 22 x 45-1/2 inches.
Source (last checked 9th May 2010):
http://www.davidsongalleries.com/artists/ichikawa/ichikawa.php
S. Tarte – 11.05.10
British Academy, London
E-Research on Texts & Images
From Signal to Meaning
Oscillations
29