

# Measuring Human Perception to Improve Handwritten Document Transcription

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Department of Computer Science and Engineering  
University of Notre Dame



Has the AI renaissance solved handwritten document transcription?

cum autē. pratis. paludib; quoq; ac salinis om̄ib; a mari usq; ad muros dicte  
ciuitatis. ⁊ cū om̄ib; possessionib; positā in monte sc̄i Stephani. plantiis ⁊ curte  
Senogallie de iure ep̄atus Senogalien̄. ⁊ Curte que uocat̄ Trebasilice. cū castello  
qd̄ uocatur Orziolo cū om̄ib; hominib; ⁊ eoz; bonis. et suis p̄uentiis. ⁊ Castrū vacca-  
rii. Castrum Ramusceri. et Castellare filioꝝ leonis. et Castellare Scorzaleporis.

*Liber septimus regestorum domini Honorii pape III*


odoribus perfundente; unguentum effusum nomen tuum. 7  
 quomodo unguentum quod effusione sua odorem longe lateq;  
 dispergit: sic xpi nomen effusum e. 7 In uniuersa terra xps  
 nominatur: in omni mundo predicatur dñs. 7 Unguentum  
 enim effusum e nomen eius. 7 <sup>E. Non ut nunc</sup> Nunc moysi nomen auditur  
 quod prius iudeae tantum claudebatur angustis. Neque  
 enim grecorum quispiam meminit eius: neq; ulla gentium  
 litterarum historia de illo seu ceteris scriptum aliquid inueni  
 mus; statim <sup>ut</sup> ih̄s radiauit in mundo: eduxit secum legem & pro  
 phetas: & uere compl&um est unguentum effusum nomen  
 tuum. 7 Propter ea iuuenulae dilexerunt te. 7 Quia per sp̄m  
 sc̄m caritas di diffusa e in corda nr̄a. Congrue nomen effusio  
 nis infertur: unguentum effusum e nomen tuum. 7 Haec di  
 cens sponsa adolescentulas conspiciat; quando <sup>atq;</sup> illa sponsi patre  
 rogabit: & ad ipsum sponsum comminus loquebatur: necdū  
 adolescentulae ad erant. 7 In medijs uero precibus ingreditur  
 iuuenularum chorus: & sponsae laudatur eloquijs: propter  
 ea iuuenulae dilexerunt te: & adtraxerunt te. adolescentulae.

St. Gallen, Stiftsbibliothek, Cod. Sang. 159, p. 22 – Hieronymus, epistolae; Origenes, sermones; Cassiodorus, de anima (<https://www.e-codices.ch/en/list/one/csg/0159>)

# Objectives

- Segment the text
- Produce a faithful plaintext transcription of what appears on the page
- Perform machine translation
- Explore a text's broader context via distant reading

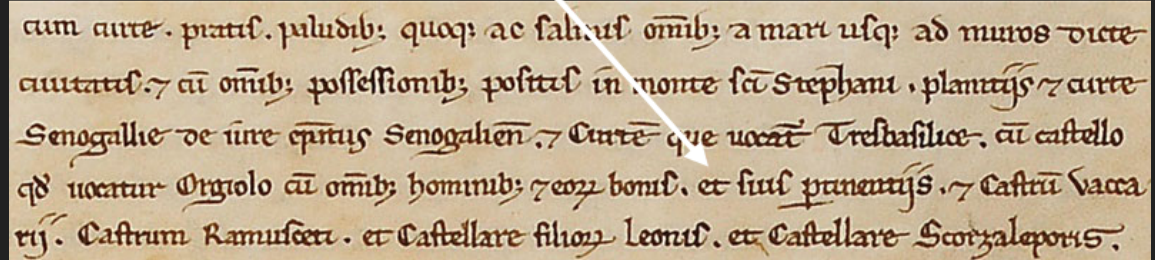
script that hasn't been used since the 13th century



cum curte. pnatil. puludib; quoq; ac salinis omib; a mari usq; ad muros dicte  
ciuitatis. 7 cū omib; possessionib; positil in monte sc̄i Stephani. plantijs 7 curte  
Senogallie de iure ep̄atus Senogahen. 7 Curte que uocat̄ Trebasilice. cū castello  
qd̄ uocatur Orziolo cū omib; hominib; 7 eozz bonil. et suis p̄tinentijs. 7 Castū Vacca  
rij. Castrum Ramusceti. et Castellare filioy Leonil. et Castellare Scorzaleporis.

*Liber septimus regestorum domini Honorii pape III*

ligature

A photograph of a manuscript page with a white arrow pointing to a specific ligature. The text is written in a Gothic script. The arrow points to the word 'Trebasilice' in the second line of the text.

cum curte. pratis. paludib; quoq; ac salinis omib; a mari usq; ad muros dicte  
ciuitatis. 7 cu omib; possessionib; positis in monte sci Stephani. plantijs 7 curte  
Senogallie de iure episcopi Senogalien. 7 Curte que uocat Trebasilice. cu castello  
qd uocatur Orgiolo cu omib; hominib; 7 eoz bonis. et suis puenentijs. 7 Castru vacca  
rij. Castrum Ramuscera. et Castellare filioy Leonis. et Castellare Scorzaleporis.

*Liber septimus regestorum domini Honorii pape III*

abbreviation

cum curte. pratis. paludib; quoq; ac salinis om̄ib; a mari usq; ad muros dicte  
ciuitatis. 7 cū om̄ib; possessionib; positis in monte sc̄i Stephani. plantijs 7 curte  
Senogallie de iure ep̄it̄is Senogalien. 7 Curte que uocat̄ Trebasilice. cū castello  
q̄d uocatur Orgiolo cū om̄ib; hominib; 7 eoz bonis. et suis p̄nentijs. 7 Castrū vacca-  
rij. Castrum Ramusceti. et Castellare filioꝝ Leonis. et Castellare Scorzaleporis.

*Liber septimus regestorum domini Honorii pape III*



“-or(um)”

cum autē . pratis . paludib; . quoq; ac salinis om̄ib; . a mari usq; ad muros dicte  
ciuitatis . 7 cū om̄ib; possessionib; positā in monte sc̄i Stephani . plantiis 7 curte  
Senogallie de iure ep̄atus Senogalien̄ . 7 Curte que uocat̄ Trebasilice . cū castello  
qđ uocatur Orgiolo cū om̄ib; hominib; 7 eoz; bonis . et suis p̄uentiis . 7 Castrū vacca  
rii . Castrum Ramusceri . et Castellare filioꝝ Leonis . et Castellare Scorzaleporis .

*Liber septimus registorum domini Honorii pape III*

punctuation

cum curte. pratis. paludib; quoq; ac salinis om̄ib; a mari usq; ad muros dicte  
ciuitatis. ⁊ cū om̄ib; possessionib; positis in monte sc̄i Stephani. plantis ⁊ curte  
Senogallie de iure ep̄isc̄i Senogallien. ⁊ Curte que uocat̄ Trebasilice. cū castello  
q̄d uocatur Orgiolo cū om̄ib; hominib; ⁊ eorū bonis. et suis p̄uentis. ⁊ Castrū vacca  
rii. Castrum Ramusceti. et Castellare filioꝝ Leonis. et Castellare Scorzalaporis.

*Liber septimus regestorum domini Honorii pape III*

# Machine Learning

- Learn a model for a task based on training data
- Success is often more related to data than the chosen learning algorithm
- Collecting data for problem domains where experts operate with specialized knowledge is difficult
- Special consideration for understanding what is easy and what is difficult



Sam Anthony



Ken Nakayama



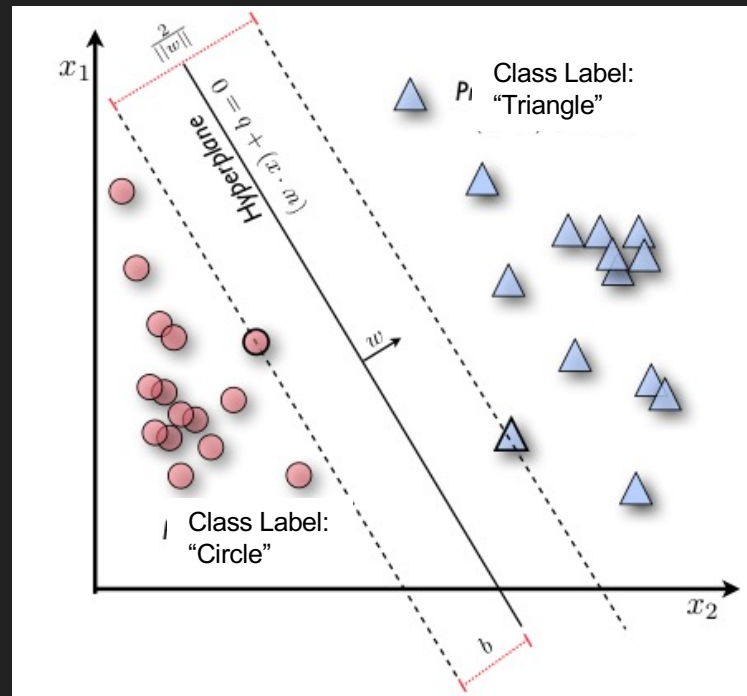
David Cox

# Perceptual Annotation: Measuring Human Vision to Improve Computer Vision

**IEEE T-PAMI, August 2014**

# Supervised Learning

A “sink or swim” approach



No effort to tailor the learning to the human ability to learn from particular images.

# Perceptual Annotation

- Much information about human capacities can be of direct value for machine learning:
  - Some images are learnable, and some are not.
  - Learnability varies with experience.
  - Some things are easily learned, other things take more time.
- Such detailed information reflecting human capacity is what we call a perceptual annotation.

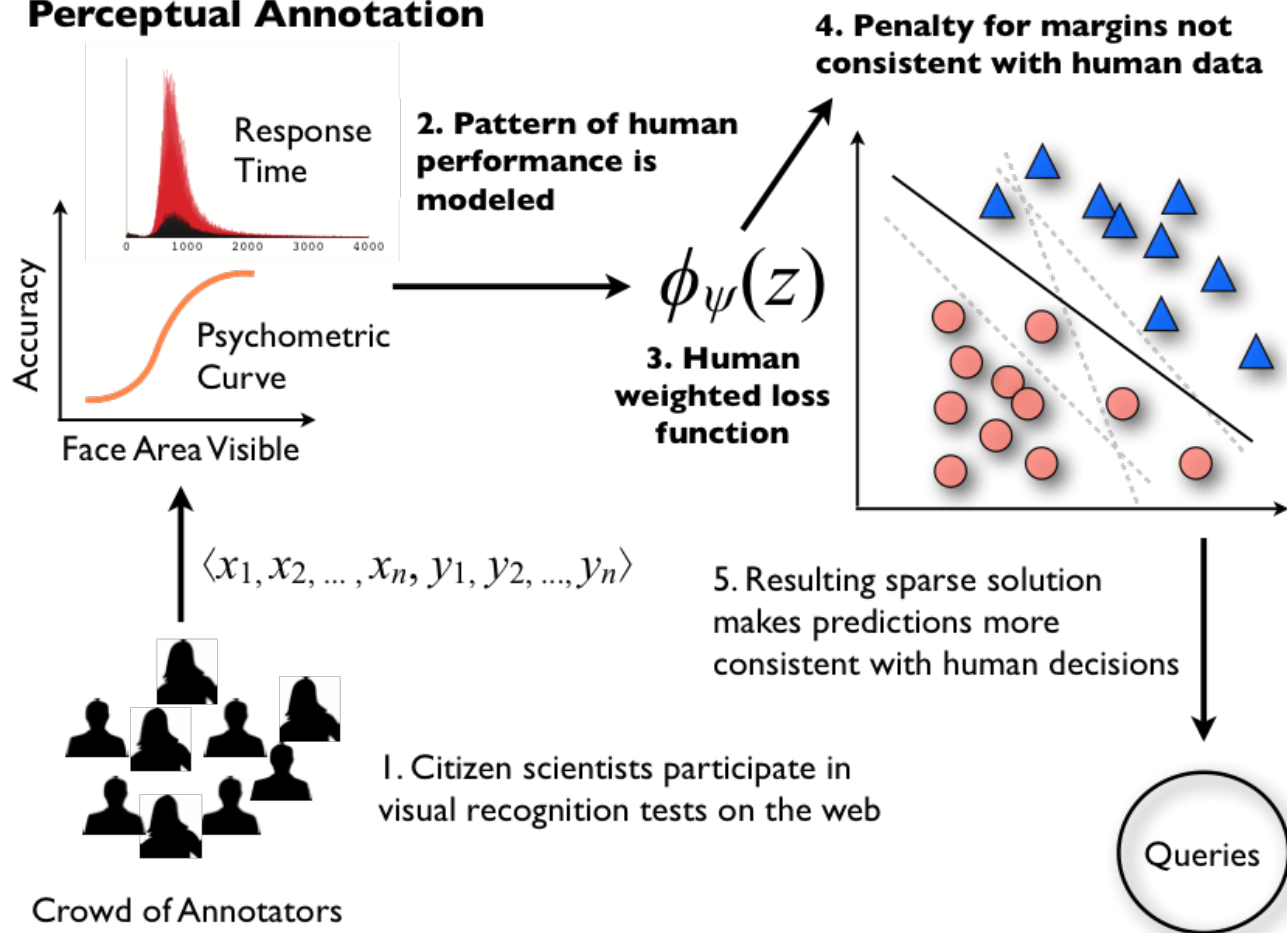
# Visual Psychophysics

Probe psychological and perceptual thresholds through controlled manipulation of stimuli.

Careful management of stimulus construction, ordering and presentation allows for precise determination of perceptual thresholds.



## Perceptual Annotation



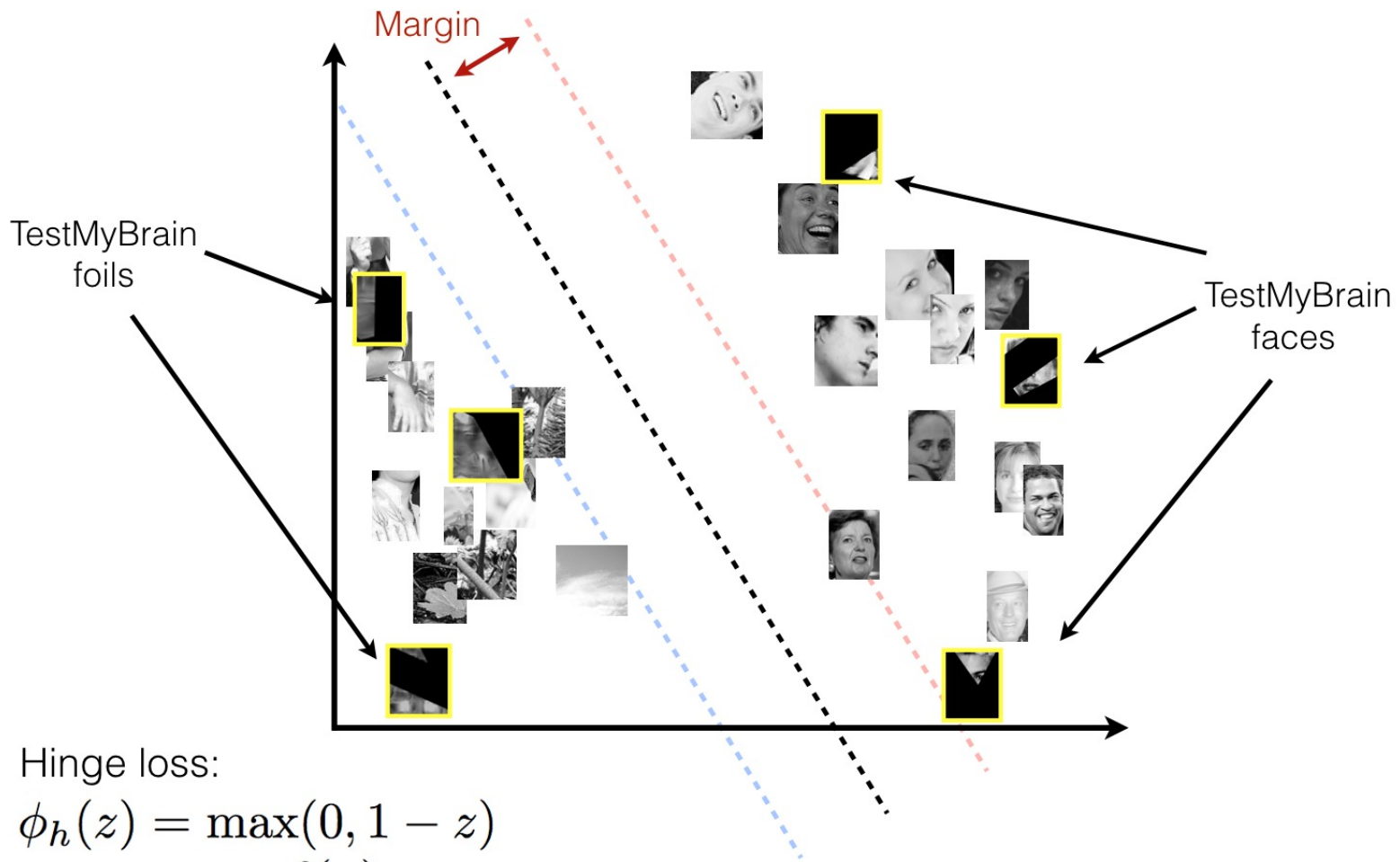


# TestMyBrain.org

## 3 Alternative Forced Choice

Press the number (1, 2 or 3) corresponding to the image with the face.

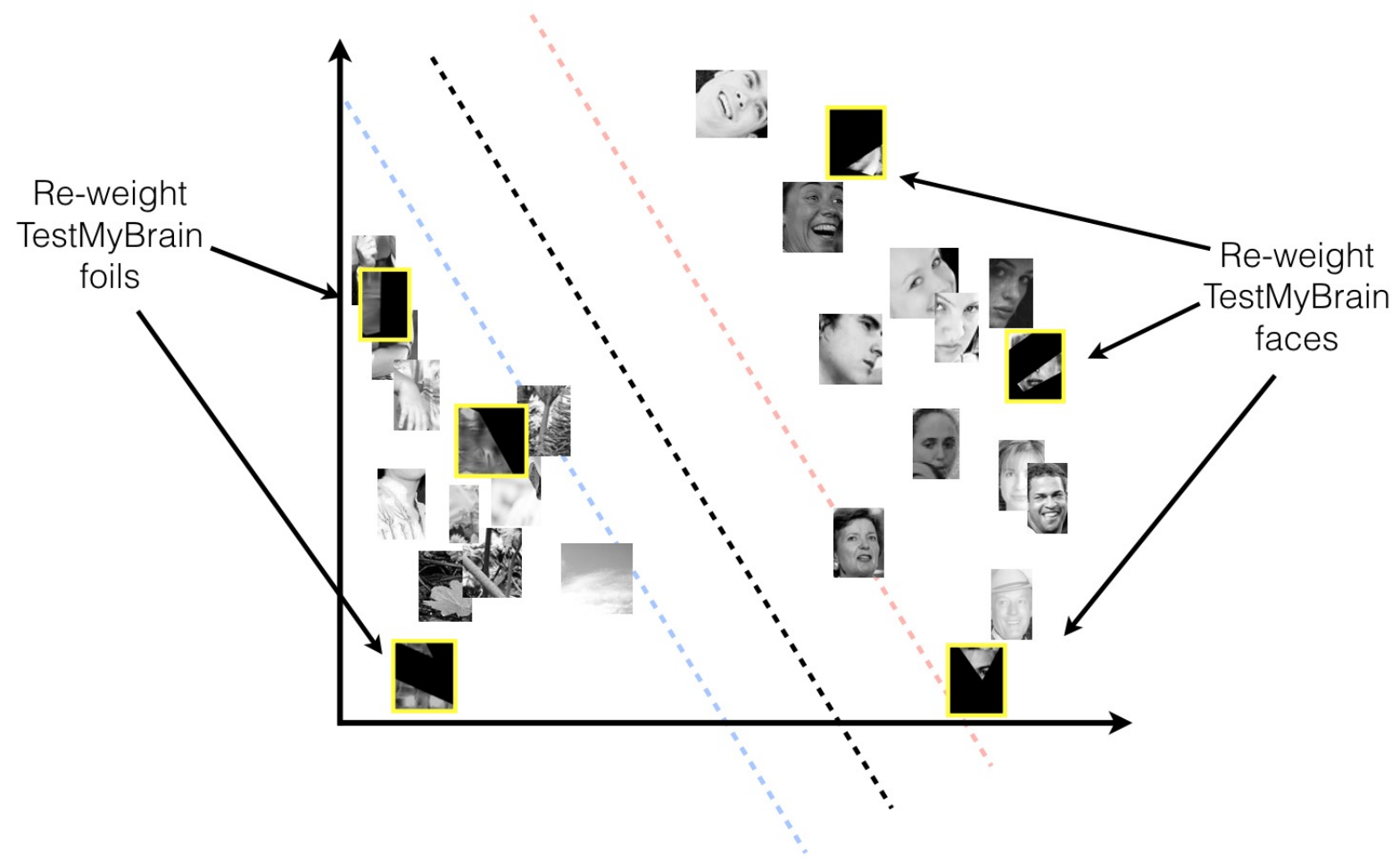


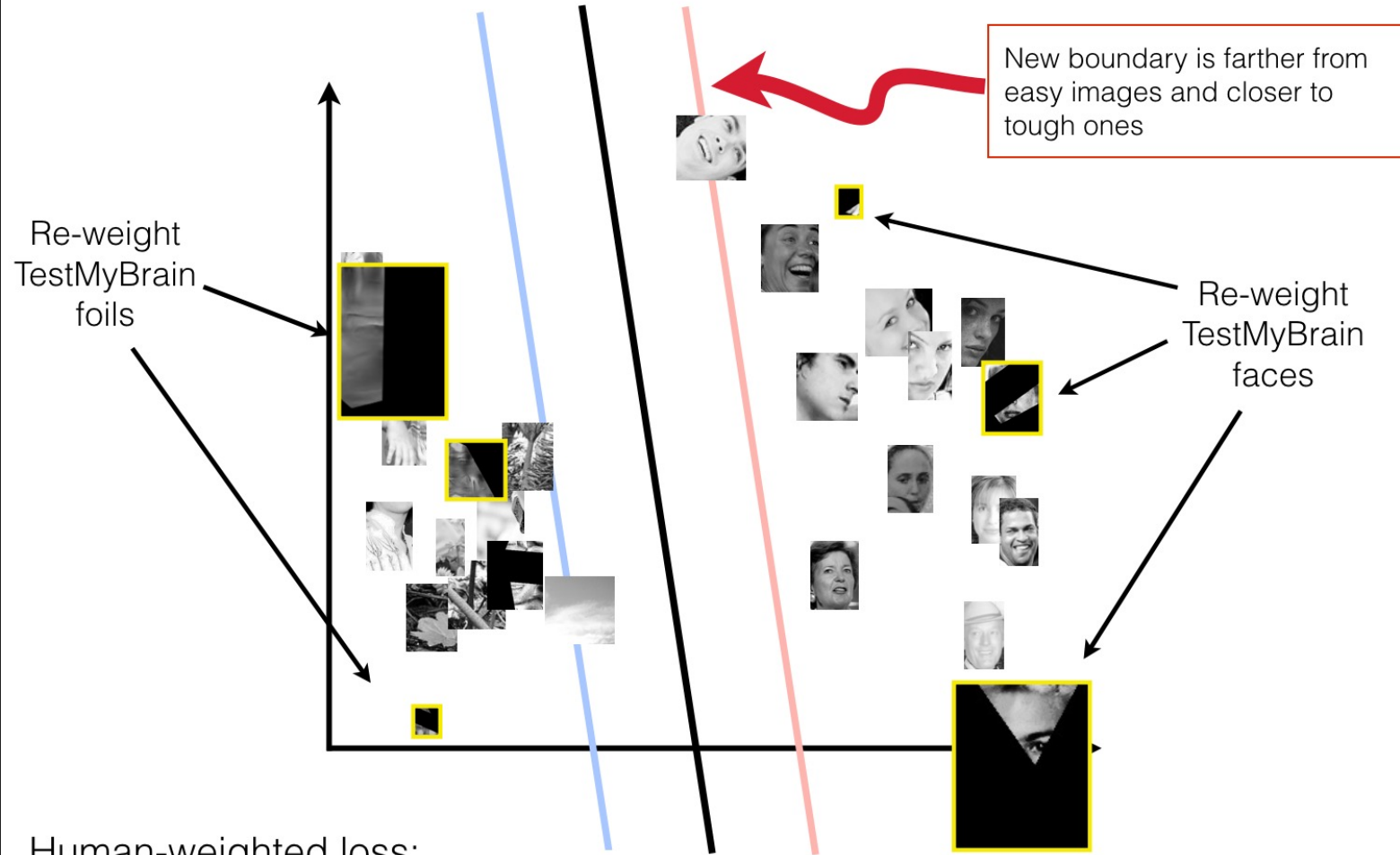


Hinge loss:

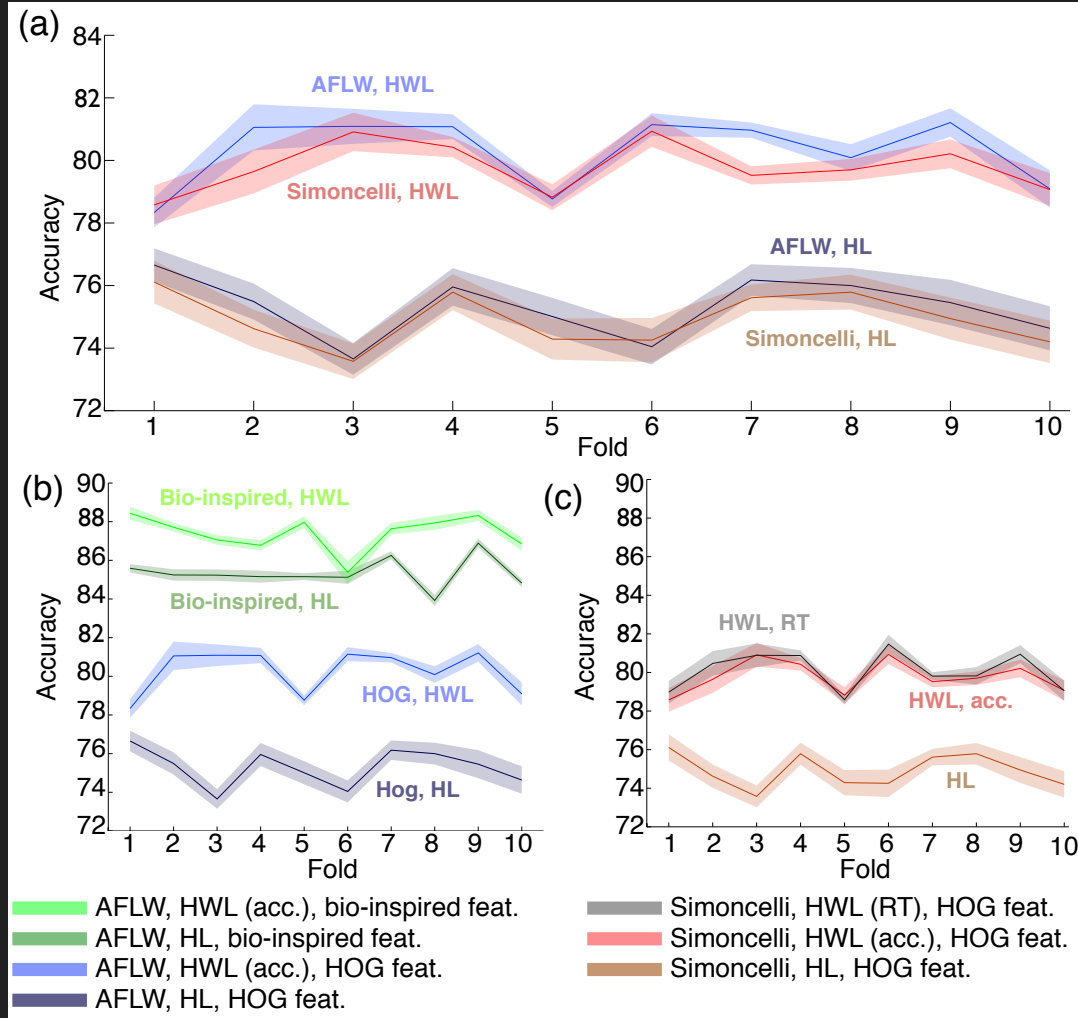
$$\phi_h(z) = \max(0, 1 - z)$$

where  $z = yf(x)$

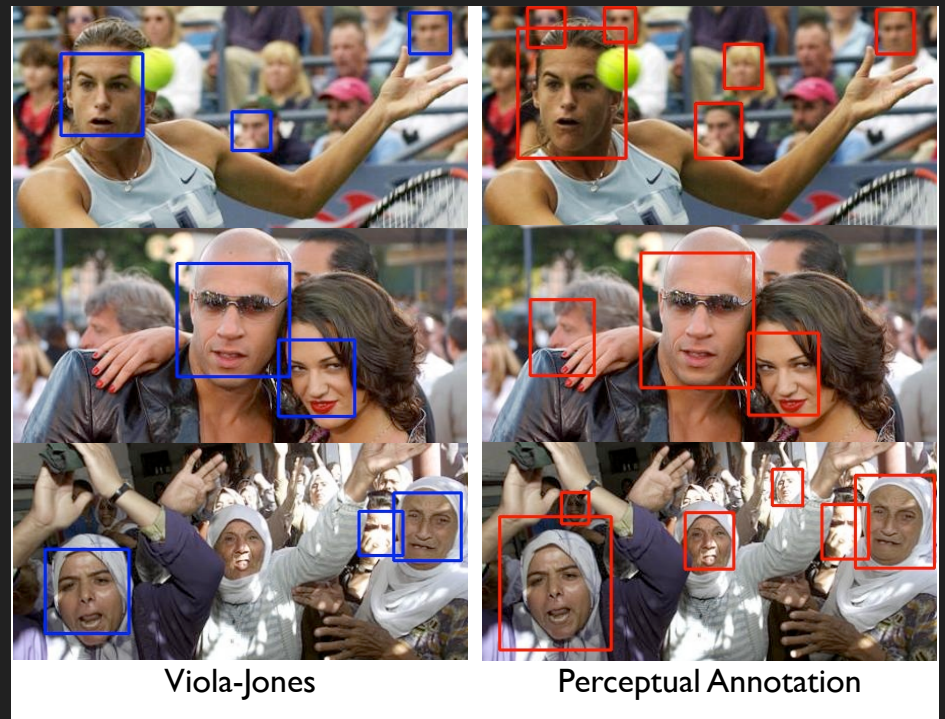
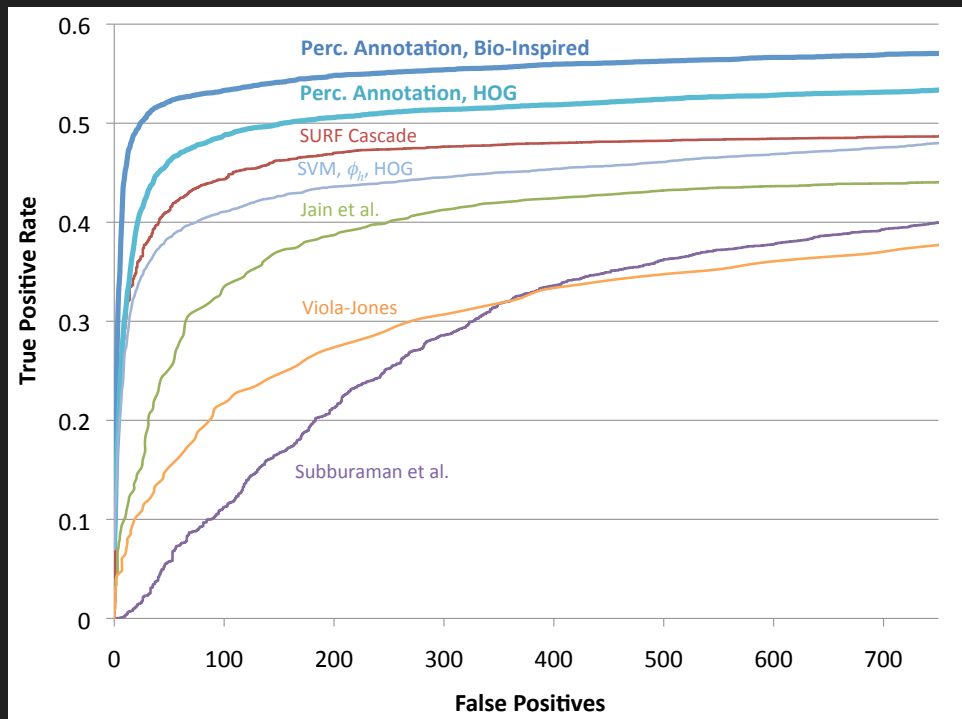




Human-weighted loss:  
 $\phi_{\psi}(x, z) = \max(0, (1 - z) + M(x, z))$

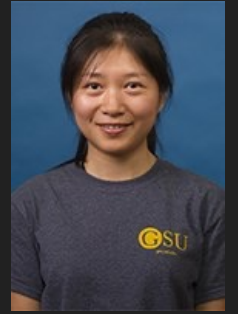


# FDDB





Sam Grieggs



Bingyu Shen

*Verba Volant, Scripta Manent*: An Open Source  
Platform For Collecting Data To Train OCR Models  
For Manuscript Studies

**Digital Humanities, July 2018**

# Measurements From Expert Annotators

- Bounding boxes at multiple levels
- Pixel-level annotation
- Reaction time
- Likert scale rating of difficulty



# The Homer Multi-Text Project

<http://www.homermultitext.org/>

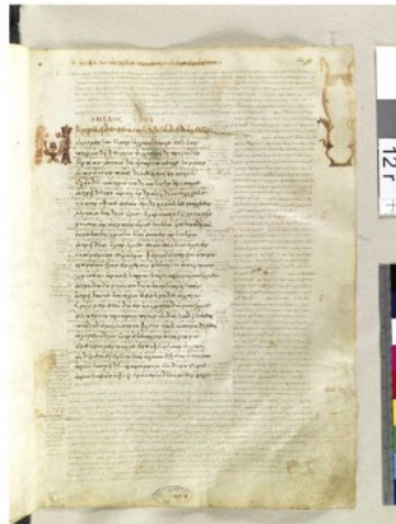
Digital services from the Homer Multitext project

HMT: [home](#) | [HMT Digital: home](#) | [browse MSS](#) | [scholia](#) | [browse MS: previous page](#) | [next page](#)

Marcianus Graecus Z. 454 (= 822) (Venetus A), folio 12r

*Iliad*1.1-1.25

(Image linked to view zoomable up to full resolution.)



([urn:cite:hmt:vaimg.VA012RN-0013](https://nbn-resolving.org/urn:nbn:de:bsz:hbz:5:1-63868-p0111-9))

Venetus A: Marcianus Graecus Z. 454 (= 822), folio 12, recto.

This image was derived from an original ©2007, Biblioteca Nazionale Marciana, Venezia, Italia. The derivative image is ©2010, Center for Hellenic Studies. Original and derivative are licensed under the Creative Commons Attribution-Noncommercial-Share Alike 3.0 License. The CHS/Marciana Imaging Project was directed by David Jacobs of the British Library.

[Cite & Quote Image](#)

Homeric epic *Iliad* A

§1

1 Μῆνιν ἄειδε θεὰ Πηληϊάδεω Ἀχιλῆος  
2 οὐλομένην· ἣ μυρ' Ἀχαιοῖς ἄλγε' ἔθηκεν·  
3 πολλὰς δ' ἰφθίμους ψυχὰς Ἴδι προΐαφεν  
4 ἠρώων· αὐτοῦς δὲ ἐλόγια τεύχε κόνεσον  
5 οἰωνοῖσι τε πάσι· Διὸς δ' ἐτελείετο βουλή·  
6 ἔξ οὗ δὴ τὰ πρῶτα διαστήτην ἐρίσαντε  
7 Ἀτρεΐδης τε ἄναξ ἄνδρῶν καὶ διὸς Ἀχιλλεύς·  
8 τίς τάρ σφωε θεῶν ἕριδι ξυνέριε μάχεσθαι·  
9 λιητοῦς καὶ Διὸς υἱός· ὁ γὰρ βασιλῆϊ χολωθεὶς  
10 νοῦσον ἀνά στρατὸν ἄρσε κακῆν· ὀλέκοντο δὲ λαοί·  
11 σῖνεκα τὸν Χρῦσῆν ἠτίμασεν ἀρητήρα  
12 Ἀτρεΐδης· ὁ γὰρ ἦλθε θοάς ἐπὶ νῆας Ἀχαιῶν·  
13 λυομένους τε θύγατρα· φέρον τ' ἀπερείσι' ἄποινα·  
14 στέμματα ἔχων ἐν χερσὶν ἐπιβόλου Ἀπόλλωνος  
15 χρυσοῦ ἀνά σκήπτρον· καὶ λίσσεται πάντας Ἀχαιοῦς·  
16 Ἀτρεΐδα δὲ μάλιστα δῶμα κοσμήτορα λαῶν·  
17 Ἀτρεΐδαί τε καὶ ἄλλοι εὐνικήμειδες Ἀχαιοί·  
18 ὅμιν μὲν θεοὶ δοῖεν Ὀλύμπια δόματ' ἔχοντες  
19 ἐκπέροισι Περσέμοιο πόλιν· εὐ δ' οἴκαδ' ἵκέσθαι·  
20 παῖδα δ' ἐμοὶ λίσσασθε φθῶν· τὰ δ' ἄποινα δεχέσθαι.  
21 ἀζόμενοι Διὸς υἱὸν ἐπιβόλον Ἀπόλλωνα·  
22 ἔνθ' ἄλλοι μὲν πάντες ἐπιπύθημασιν Ἀχαιοί·  
23 αἰδέσθαι σ' ἔγερθε καὶ ἀγλαὰ δέχεσθαι ἄποινα·  
24 ἄλλ' οὐκ Ἀτρεΐδῃ λαγόμενον ἦνδανε θυμῷ·  
25 ἄλλα κακῶς ἀφίει· κριστερόν δ' ἐπὶ μῦθον ἔτελλε·

([urn:cite:greekLit:litg0012.litg001.msA:1.1-1.25](https://nbn-resolving.org/urn:nbn:de:bsz:hbz:5:1-63868-p0111-9))

## Image Citation Tool

Right-click here to copy URN XXXXXXXXXX

urn:cite:hmt:vaimg.VA012RN-0013@0.17,0.2515,0.325,0.0263

Focus on Selection | See Selection | Selection in Context



Christopher Blackwell and Neel Smith, <https://github.com/cite-architecture/ict2>

grieggs / Psychometric-Annotator

Unwatch 1 Star 0 Fork 0

Code Issues 0 Pull requests 0 Projects 0 Wiki Insights Settings

A software package designed to facilitate the creation of ground truth data for Medieval Manuscript OCR. Edit

digital humanites data collection annotations Manage topics

43 commits 1 branch 0 releases 1 contributor

Branch: master New pull request Create new file Upload files Find file Clone or download

grieggs Update README.md Latest commit 85d8d7c 4 minutes ago

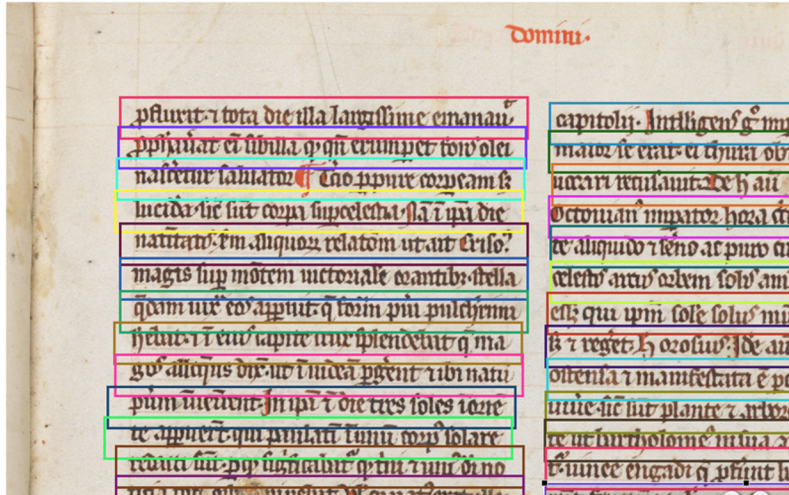
.idea	forced forms to reset on new loads.	10 months ago
ImageArchive	set up the directories	26 days ago
ImageHandler	fixed another little glitch with the dockerfile.	5 days ago
Psychometric-Annotator	Added automatic processing of document images	7 days ago
data	Added automatic processing of document scans	7 days ago
database	set up the directories	26 days ago
output	Lots of work towards reconstructing the documents	25 days ago
scripts	Added automatic processing of document scans	7 days ago
src/main	Added automatic processing of document images	7 days ago

Software: <https://github.com/grieggs/Psychometric-Annotator>

### Line Selector v.0.0.1

Address will go here

Draw a rectangle around each line of text. Press "C" to begin. Make sure to select every line of the main body of text on the page, in order from top to bottom. When finished, press submit. The image might take a moment to load.

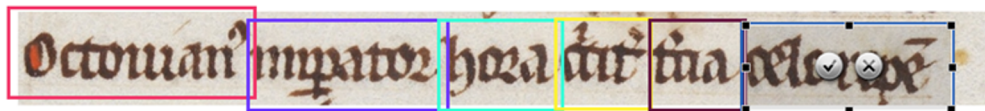


### Line URNs

- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0919f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0905f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0892f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0878f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0919f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0919f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0919f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0872f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0878f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0819f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0792f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0884f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.0884f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4415f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4409f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4436f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4409f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4421f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4421f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4394f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4382f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4394f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4382f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4374f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4382f

### Word Selector v.0.0.1

Draw a rectangle around each word. Press "C" to begin. Make sure to select each visible word in the order in which they should be read based off of the source material. When finished, press submit. The image might take a moment to load.



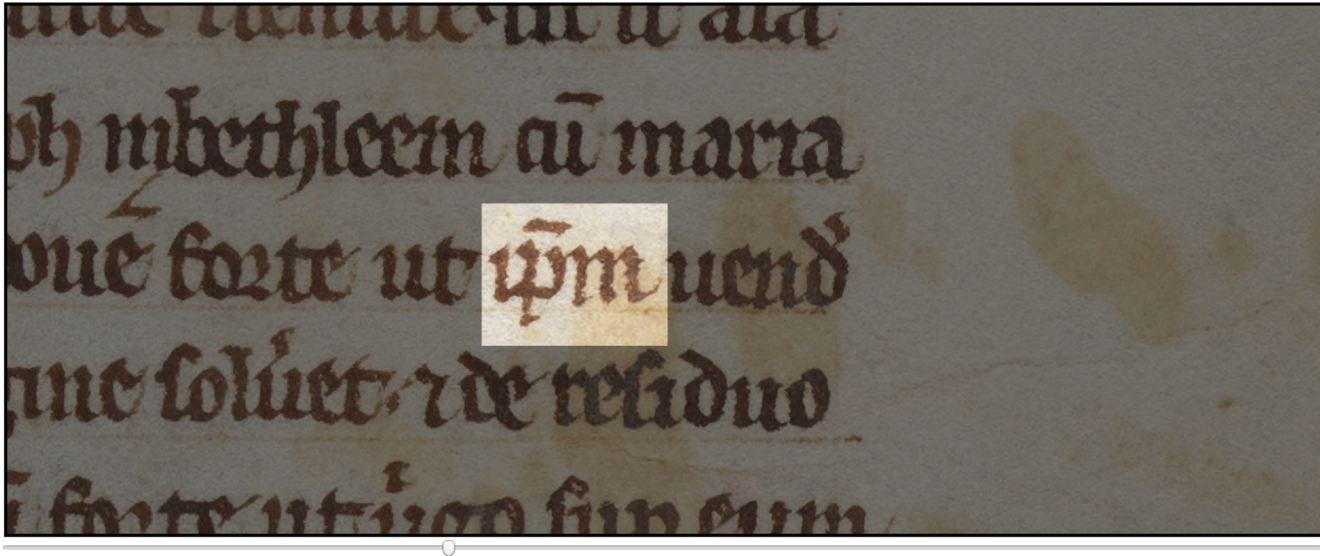
### Word URNs

- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.4372f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.5177f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.5817f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.6211f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.6527f
- ▶ [x] urn:cite2:ecod:vaimg.v1:einstift\_018r@0.6837f

Submit

Character Selector v.0.0.1

Trace out each individual letter to segment them. To start on to the next letter click the "Add Annotation" button. Include accents with the characters they are most associated with. Press submit when finished.



Annotations:

1

a <sub>a</sub>	b <sub>b</sub>	c <sub>c</sub>	d <sub>d</sub>	e <sub>e</sub>
f <sub>f</sub>	g <sub>g</sub>	h <sub>h</sub>	i <sub>i</sub>	l <sub>l</sub>
m <sub>m</sub>	n <sub>n</sub>	o <sub>o</sub>	p <sub>p</sub>	q <sub>q</sub>
r <sub>r</sub>	s <sub>s</sub>	t <sub>t</sub>	u <sub>u</sub>	x <sub>x</sub>
y	z	~	7 <sub>n</sub>	p <sub>p</sub>
p <sub>p</sub>	q <sub>q</sub>	z <sub>z</sub>	p <sub>p</sub>	o <sub>o</sub>
.	;	-	.	?
		(accent)		other

Add Annotation

Annotation Tools:

Zoom:

Brush Size:

Active Annotation:

1

Reset Active Annotation

Undo last mark

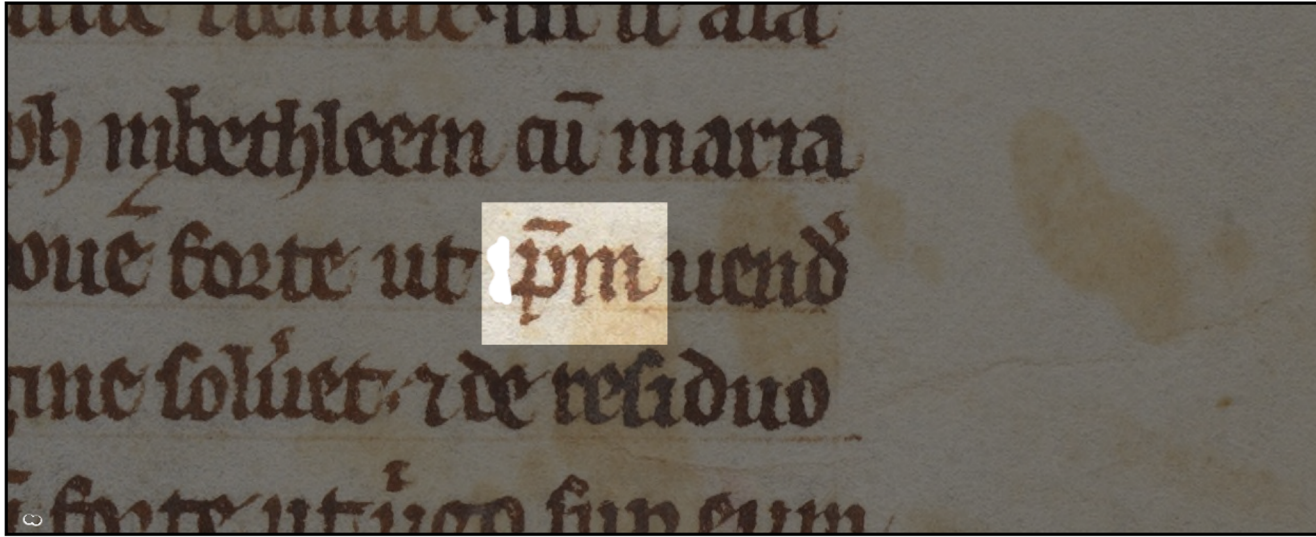
Delete Active Annotation

Submit

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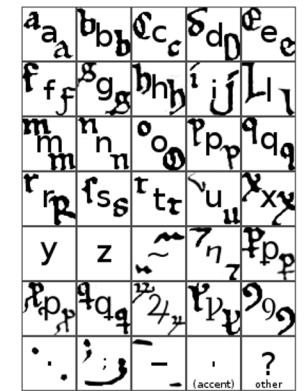
## Character Selector v.0.0.1

Trace out each individual letter to segment them. To start on to the next letter click the "Add Annotation" button. Include accents with the characters they are most associated with. Press submit when finished.



Annotations:

i



Annotation Tools:

Zoom:

Brush Size:

Active Annotation:

1

Reset Active Annotation

Undo last mark

Delete Active Annotation

Submit

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## Character Selector v.0.0.1

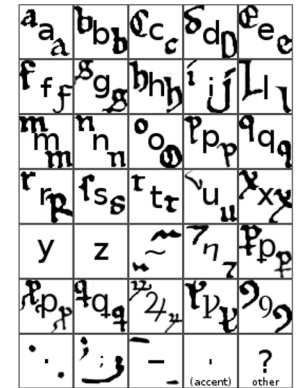
Trace out each individual letter to segment them. To start on to the next letter click the "Add Annotation" button. Include accents with the characters they are most associated with. Press submit when finished.



Annotations:



p



Add Annotation

Annotation Tools:

Zoom:

Brush Size:

Active Annotation:

2

Reset Active Annotation

Undo last mark

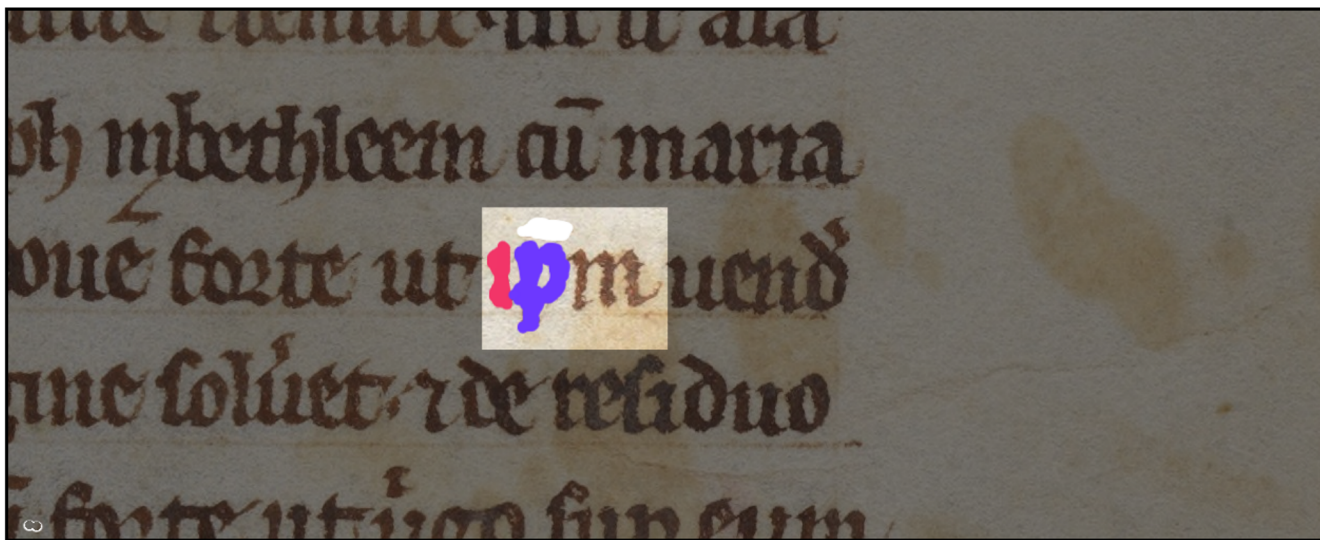
Delete Active Annotation

Submit

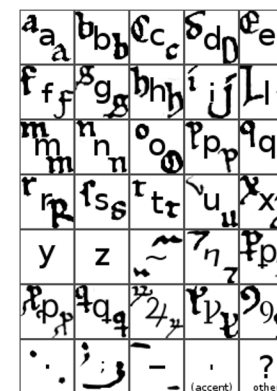
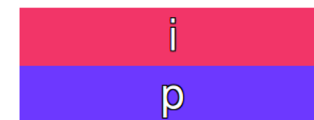
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Trace out each individual letter to segment them. To start on to the next letter click the "Add Annotation" button. Include accents with the characters they are most associated with. Press submit when finished.



Annotations:



Add Annotation

Annotation Tools:

Zoom:

Brush Size:

Active Annotation:

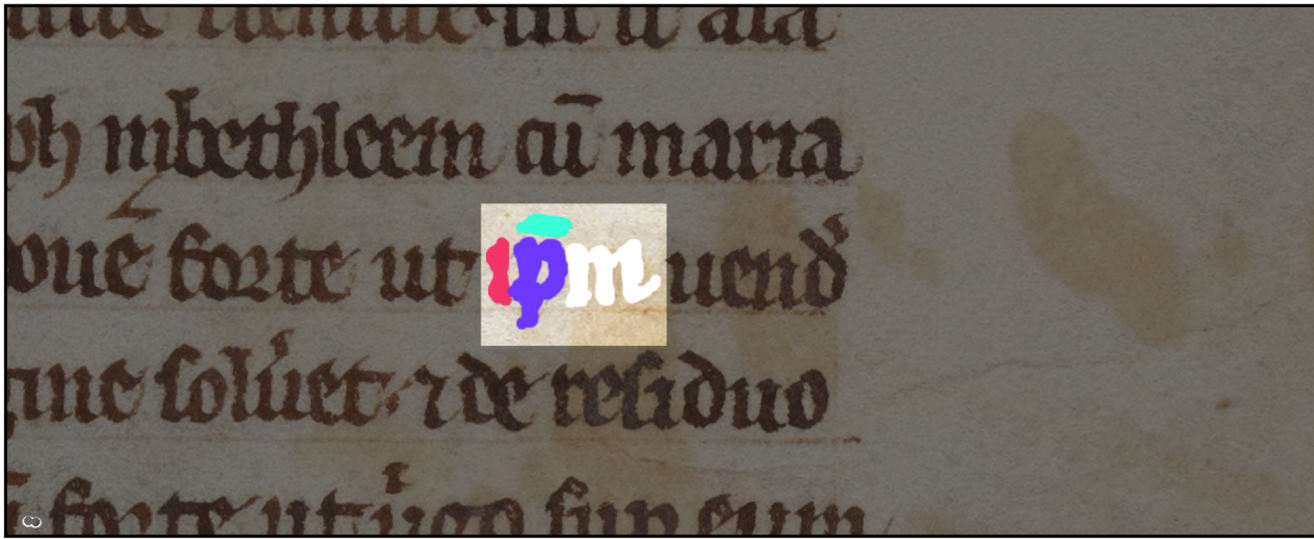
3 ▾

CITE/CTS is ©2002–2017 Neel Smith and Christopher Blackwell. This software is based off of the tool for working with images cited via CITE2 URNs which is ©2017 by Christopher Blackwell. This software and Christopher Blackwell's ICT2 are available for use, modification, and distribution under the terms of the GPL 3.0 license. This software is based on Openseadragon.

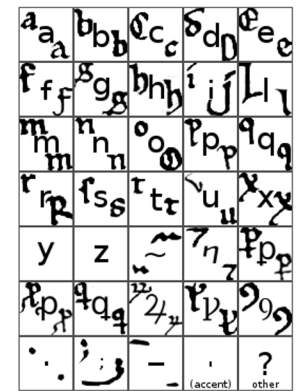
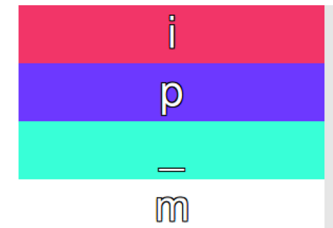


Character Selector v.0.0.1

Trace out each individual letter to segment them. To start on to the next letter click the "Add Annotation" button. Include accents with the characters they are most associated with. Press submit when finished.



Annotations:



Add Annotation

Annotation Tools:

Zoom:

Brush Size:

Active Annotation:

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### Character Annotator v.0.0.1

Simply input the character shown into the text box and then rate on a scale of 1-10 how difficult it was to transcribe. Click The button below to start. Note that the button might take a moment to load.



Character Input

h

a	a	b	b	c	c	d	d	e	e
f	f	g	g	h	h	i	i	l	l
m	m	n	n	o	o	p	p	q	q
r	r	s	s	t	t	u	u	x	x
y	z	~	~	7	7	p	p		
p	p	q	q	2	2	v	v	9	9
.	.	-	-	.	.	;	;	?	?
				(accent)				other	

Difficulty (0 being very easy and 7 being very difficult):

0  7

3

Submit

predicatur dñs. Unguentum  
enim effusum ē nomen eius. Nunc moti nomen audetur

predicatur dñs. Unguentum  
enim effusum ē nomen eius. Nunc moti nomen audetur

qm̄ caritas dī diffusa ē in corda nr̄a. Congruo nomen effusio

qm̄ caritas dī diffusa ē in corda nr̄a. Congruo nomen effusio

predicatur dñs. Unguentum  
enim effusum ē nomen eius. Nunc moti nomen audetur

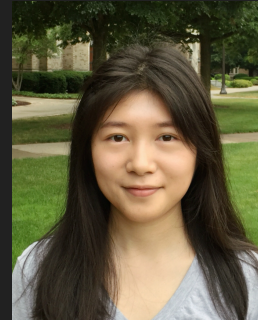
predicatur dñs. Unguentum  
enim effusum ē nomen eius. Nunc moti nomen audetur

qm̄ caritas dī diffusa ē in corda nr̄a. Congruo nomen effusio

qm̄ caritas dī diffusa ē in corda nr̄a. Congruo nomen effusio



Sam Grieggs



Bingyu Shen



Maria Ma



Brian Price

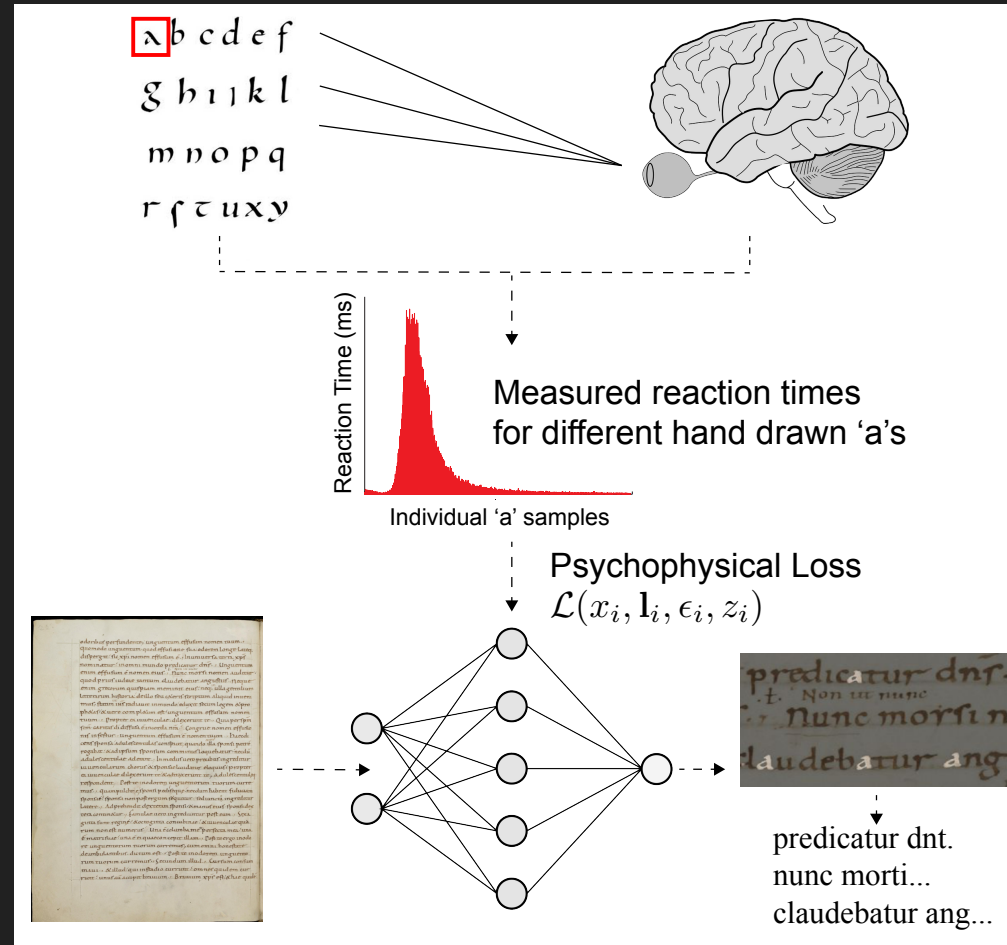
# Measuring Human Perception to Improve Handwritten Document Transcription

arXiv, April 2019

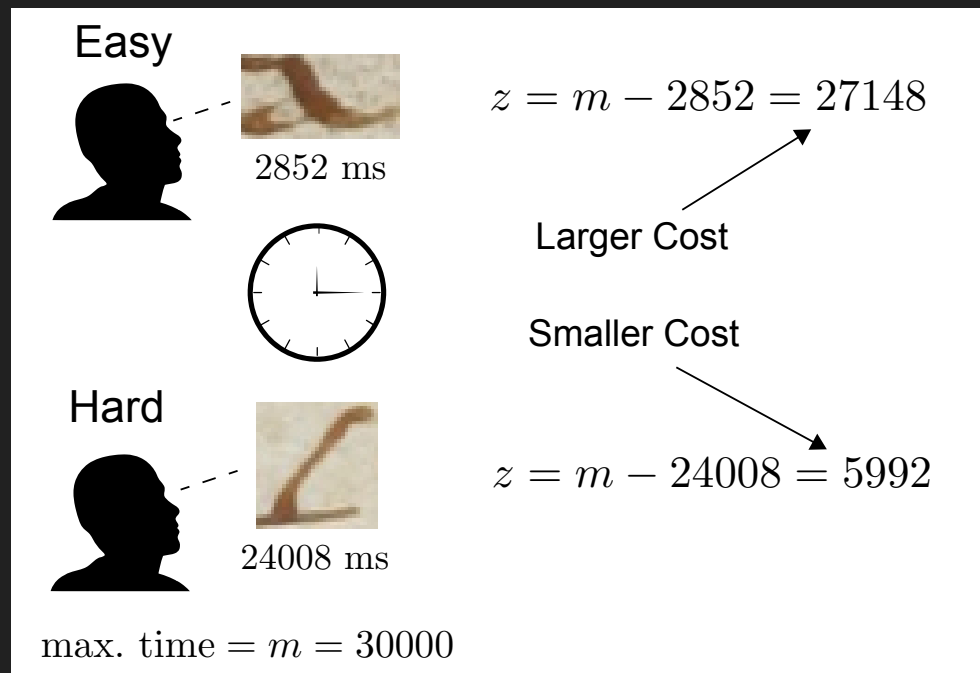
# Objective: Psychophysical Loss for Neural Networks

- Incorporate measurements of human vision into the training process of a CNN
  - Original perceptual annotation approach only applied to classifiers
- Build a transcription pipeline that really works
  - Too much emphasis on beating datasets in this area

# Perceptual Annotation for a Neural Network



# Assigning Penalties for a Reading Task



# CTC Loss

$$\mathcal{L}_{\text{CTC}} = - \sum_{x_i, \mathbf{l}_i \in \mathcal{X}} \log p(\mathbf{l}_i | \mathbf{y}_i)$$

Sequence Produced by Network

Training Image      Ground-Truth Label Sequence      Training Data Set



# Psychophysical Loss

Calculate a psychophysical penalty for images

Sorted reaction times:  $R = \{r_1, \dots, r_n\}$


Maximum reaction time:  $m = \max(R)$

Psychophysical penalty:  $z_i = m - r_i$

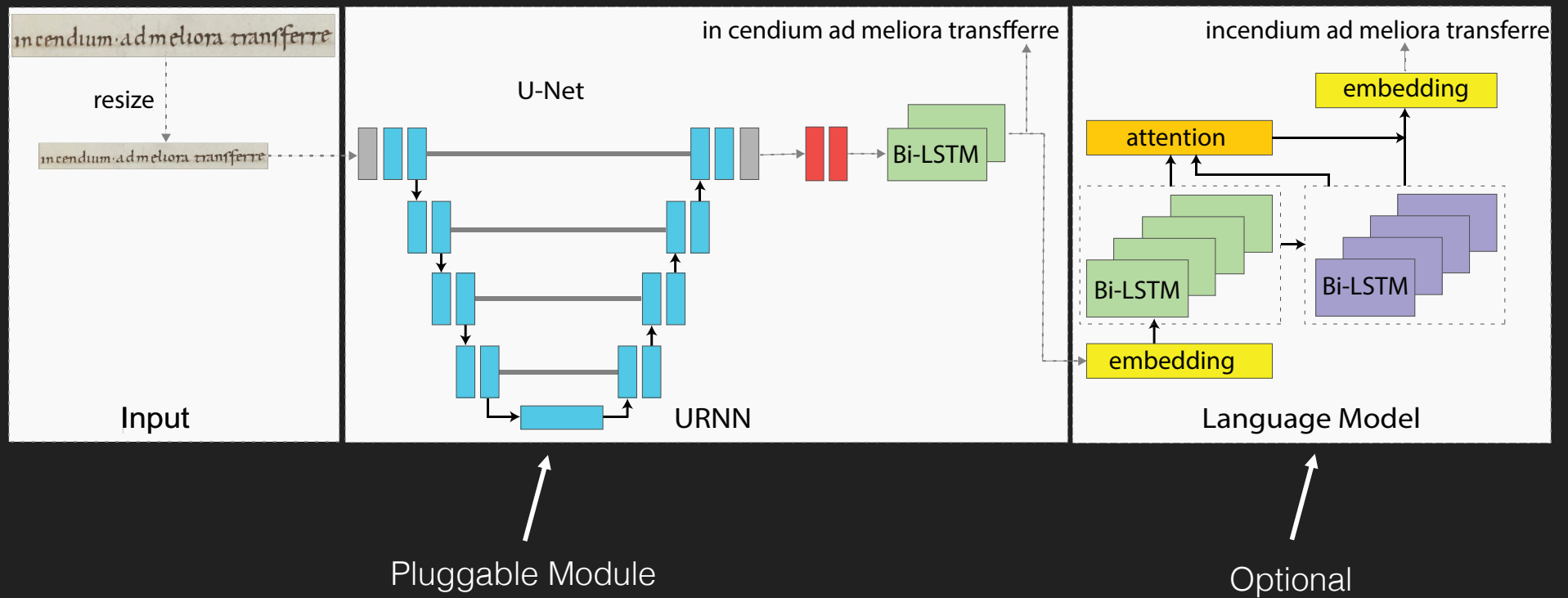
# Psychophysical Loss

$$\mathcal{L}_{\text{psych}} = \sum_{x_i, \epsilon_i, \mathbf{l}_i \in \mathcal{X}} -\log p(\mathbf{l}_i | \mathbf{y}_i) + (\epsilon_i \times z_i)$$

Associated  
Character  
Error Rate

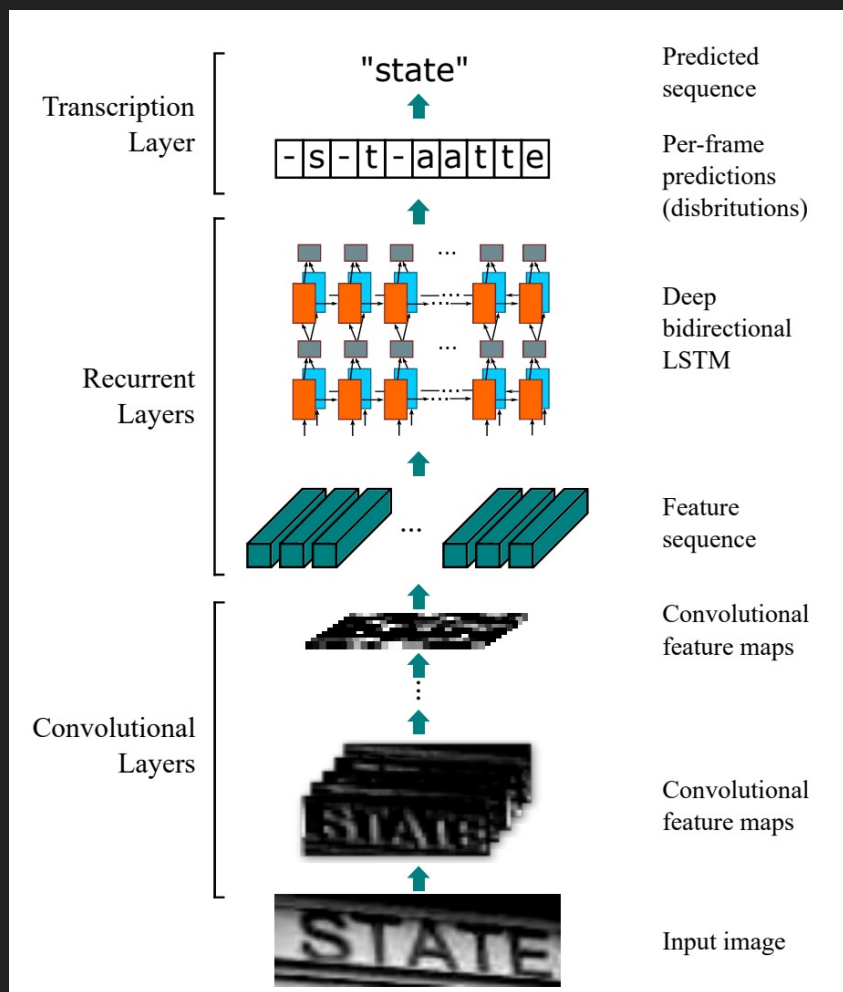


# Network Architecture



# Another choice for transcription: CRNN

Shi et al. T-PAMI 2017



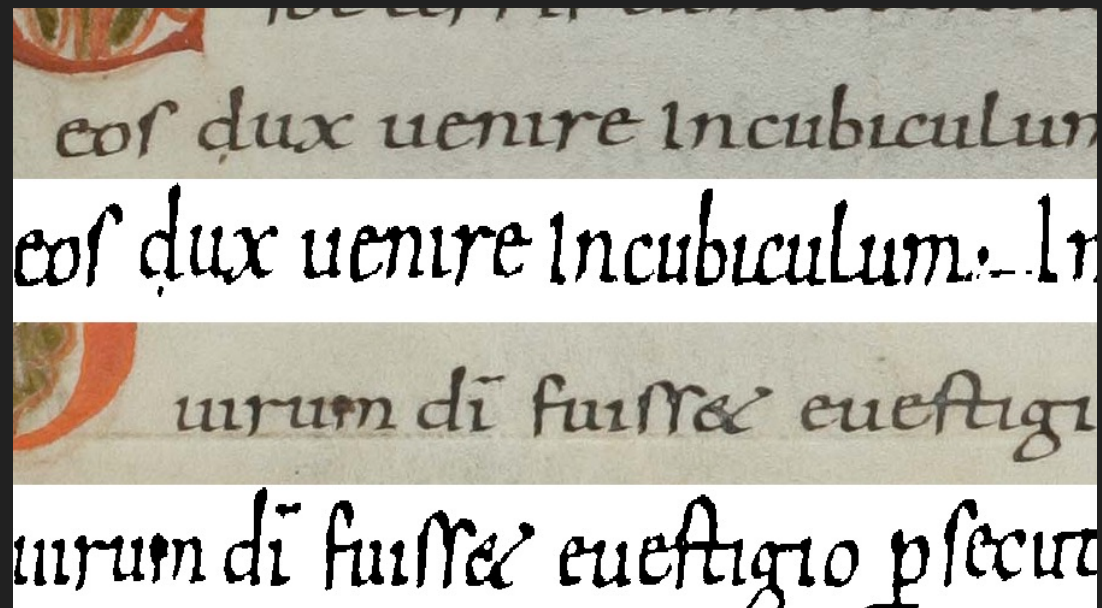
# Results

---

He slapped himself in the face and cuffed the sides of his head. Then by degrees the rotating objects slowed, and coming into focus took the form of the furnishings in Dan Brown's living room. He stood up unsteadily and looked about the room, trying to gather his wits. Outside the dusk was settling over Dow's Lake and the heights beyond were in silhouette, already a solid black.

---

He slapped himself in the face and cuffed the sides of his head. Then by degrees the rotating objects slowed, and coming into focus took the form of the furnishings in Dan Brown's living room. He stood up unsteadily and looked about the room, trying to gather his wits. Outside the dusk was settling over Daw's Lake and the heights beyond were in ~~the~~ silhouette, already a solid black.



A. Fischer, V. Frinken, A. Fornes, and H. Bunke. Transcription alignment of Latin manuscripts using hidden Markov models. In Proceedings of the 2011 Workshop on Historical Document Imaging and Processing, pages 29–36. ACM, 2011.

odoribus perfundente; unguentum effusum nomen tuum. 7  
 quomodo unguentum quod effusione sua odorem longe lateq:  
 dispergit: sic xpi nomen effusum e. 7 In uniuersa terra xpi  
 nominatur: in omni mundo predicatur dñs. 7 Unguentum  
 enim effusum e nomen eius. 7 <sup>E. Non ut nunc</sup> Nunc moysi nomen auditur  
 quod prius iudeae tantum claudebatur angustis. Neque  
 enim grecorum quispiam meminit eius: neq: ulla gentium  
 litterarum historia de illo seu ceteris scriptum aliquid inueni  
 mus; statim <sup>ut</sup> ih̄s radiauit in mundo: eduxit secum legem & pro  
 phetas: & uere compl&um est unguentum effusum nomen  
 tuum. 7 Propter ea iuuenulae dilexerunt te. 7 Quia per sp̄m  
 sc̄m caritas di diffusa e in corda nr̄a. Congrue nomen effusio  
 nis infertur: unguentum effusum e nomen tuum. 7 Haec di  
 cens sponsa adolescentulas conspiciat; quando <sup>adit</sup> illa sponsi patre  
 rogabit: & ad ipsum sponsum comminus loquebatur: necdū  
 adolescentulae adierant. 7 In medijs uero precibus ingreditur  
 iuuenularum chorus: & sponsae laudatur eloquijs: propter  
 ea iuuenulae dilexerunt te: & adtraxerunt te. adolescentulae.

St. Gallen, Stiftsbibliothek, Cod. Sang. 159, p. 22 – Hieronymus, epistolae; Origenes, sermones; Cassiodorus, de anima (<https://www.e-codices.ch/en/list/one/csg/0159>)



# Does it work?

Input	<i>comparing the failure of a subsidized duke</i>	<i>dn̄s ad memoriā illius dedaravit</i>
URNN	comparing the failure of a subsidized duke	dominus ad memoriem illius dedaravit
LM	composing the failure of a subsidized duke	dominus ad memoriam illius dedaravit
GT	comparing the failure of a subsidized duke	dominus ad memoriam illius declaravit
Input	<i>a grey superimposition of respectability over</i>	<i>et missis post virum dei legatis eum advenire devote rogare!</i>
URNN	a grey superimposition of respectability over	et missis post virum dei legatis eum ad venire devote rogaret
LM	a grey superimposition of respectability over	et missis post virum dei legatis eius advenire devote rogaret
GT	a grey superimposition of respectability over	et missis post virum dei legatis eum advenire devote rogaret
Input	<i>the original colour of his own natural vowels,</i>	<i>largiatur; nos similitudinem auri faciemus; non habemus aurum;</i>
URNN	the original colour of his own natural vowels,	largiatur nos similitudinem auri faciemus non habemus aurum
LM	the original colour of his own natural vowels,	largiatur nos similitudinem auri faciemus non habemus aurum
GT	the original colour of his own natural vowels,	largiatur nos similitudinem auri faciemus non habemus aurum

# What impact does psychophysical loss have?

IAM

	CRNN			URNN		
	val1	val2	test	val1	val2	test
CER (% Improvement)	3.06	5.29	4.19	5.65	8.27	4.74
WER (% Improvement)	2.83	3.73	3.76	3.65	6.46	3.47

Practical impact: average of 598 character errors and 295 word errors were eliminated

# What impact does the language model have?

IAM

	CRNN w/ Language Model Correction						URNN w/ Language Model Correction					
	w/o Psych. Loss			w/ Psych. Loss			w/o Psych. Loss			w/ Psych. Loss		
	val1	val2	test	val1	val2	test	val1	val2	test	val1	val2	test
CER (% Improvement )	-0.67	-0.93	-1.45	-1.02	-0.20	-1.87	-6.92	-7.36	-7.10	-4.47	-4.77	-4.95
WER(% Improvement )	27.99	24.32	24.38	27.21	24.38	23.72	22.98	22.11	21.71	27.31	25.44	23.68

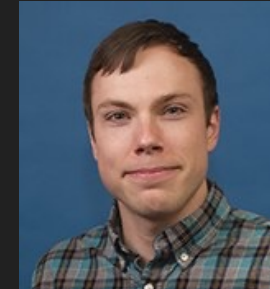
# Off-the-Shelf tools popular in Digital Humanities

## St. Gall

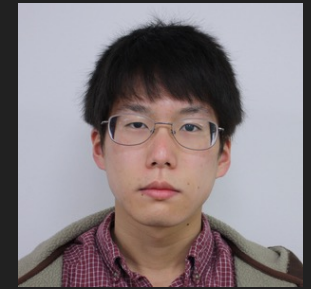
	Ocular		OCRopus		Tesseract		CRNN + LM		URNN + LM	
	CER	WER	CER	WER	CER	WER	CER	WER	CER	WER
IAM [39]	92.83	122	33	43.1	55.71	96.10	9.7 (9.9)	30.8 (23.49)	<b>7.8 (7.86)</b>	24.7 ( <b>18.71</b> )
St. Gall [26]	90.2	143.8	71	102.4	39.71	94.74	9.1 (9.42)	35.7 (28.04)	<b>8.7 (9.09)</b>	30.0 ( <b>26.04</b> )
All Latin	90.9	138.2	62.9	94.2	51.69	124.09	12.4 (12.87)	44.0 (37.4)	<b>10.4 (10.63)</b>	34.7 ( <b>30.51</b> )

Where do we go after we transcribe  
the registers?

# Tesserae Project



Jeff Kinnison



Nozomu Okuda

The screenshot shows the Tesserae website interface. At the top left is the logo and the word "TESSERAE". Below it are navigation links: SEARCH, OTHER TOOLS, SOURCES, and AB. A search bar is present with options to sort by "decreasing" and "score", and to show "100" results at a time. Below the search bar, it indicates "737 results in 8 pages" and provides pagination options: "Go to page: 1 2 3 4 5 [next]".

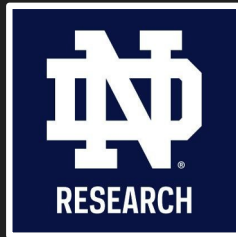
A detailed view of a match is shown in a pop-up window. It displays the "target phrase" and "source phrase" with the matching words highlighted in red. Below this, a table shows the "matched on" words and their "score".

target phrase	source phrase	matched on	score
<a href="#">verq. q. 1.423</a> et laetae pecudes et ovantes <b>guttire corvi.</b>	<a href="#">cat. 108.5</a> effossos oculos voret atro <b>guttire corvus,</b>	guttur, coruus	9

	target phrase	source phrase	matched on	score
1.	<a href="#">verq. q. 1.21</a> <b>dique deaeque</b> omnes, studium quibus arva tueri,	<a href="#">cat. 28.14</a> at vobis mala multa <b>di deaeque</b>	dea-deferuesco, deus-dius	9
2.	<a href="#">verq. q. 1.40</a> da facilem cursum atque audacibus <b>adnue coeptis</b>	<a href="#">cat. 68b.48</a> <b>cooperat ad</b> sese Troia ciere viros,	ad, coepi	9
3.	<a href="#">verq. q. 1.423</a> et laetae pecudes et ovantes <b>guttire corvi.</b>	<a href="#">cat. 108.5</a> effossos oculos voret atro <b>guttire corvus,</b>	guttur, coruus	9

<https://tesserae.caset.buffalo.edu/>



## Supported by:

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