A robust stamp detection framework on degraded documents

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Challenges in stamp detection

- Unique characteristics of stamps
  - Unstable and unpredictable patterns in documents
  - Outliers and occlusions are typical
  - Much lower spatial density compared to logo
  - Stamp instances appear as weaker regions within a full spectrum of background – text, figures, tables, watermark
  - Not generally valid to assume its location within the source

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ЛИЦЕНЗИЯ

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НА ДЕЯТЕЛЬНОСТЬ В ОБЛАСТИ ЗАЩИТЫ ИНФОРМАЦИИ

Государственный центр безопасности информации при Совете Безопасности Республики Беларусь разрешает осуществление на территории Республики Беларусь следующих видов деятельности:

Реализация, монтаж, наладка, сервисное обслуживание программно-аппаратных средств защиты от несанкционированного доступа, в том числе с применением средств криптографии.

Лицензия выдана Иностранное унитарное частное производственно-торговое предприятие «СИСТЕМНЫЕ ТЕХНОЛОГИИ» компании «ТРЕЛБОРГ ТРЕЙДИНГ ЛИМИТЕД», г. Минск, ул. Минина, 23а, 2 этаж.

Особые условия осуществления лицензионного вида деятельности:

Программно-аппаратные средства защиты от несанкционированного доступа, в том числе с применением средств криптографии, реализуются после обязательной экспертизы в Государственном центре безопасности информации.

Деятельность в государственном секторе осуществляется после согласования с Государственным центром безопасности информации.

Лицензия действительна до «20» января 2006 г.

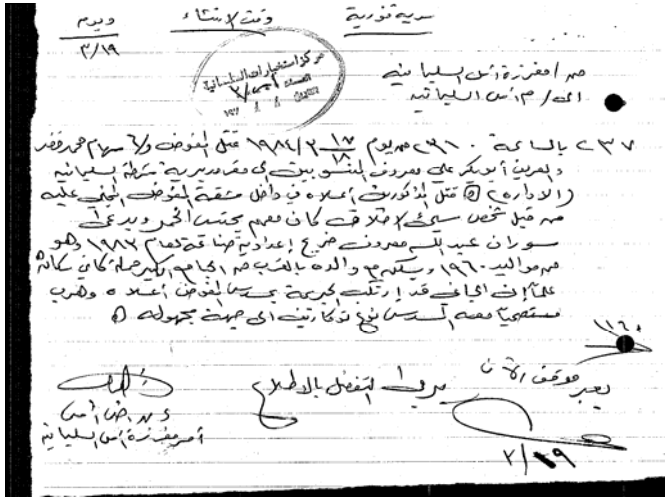
НАЧАЛЬНИК ЦЕНТРА

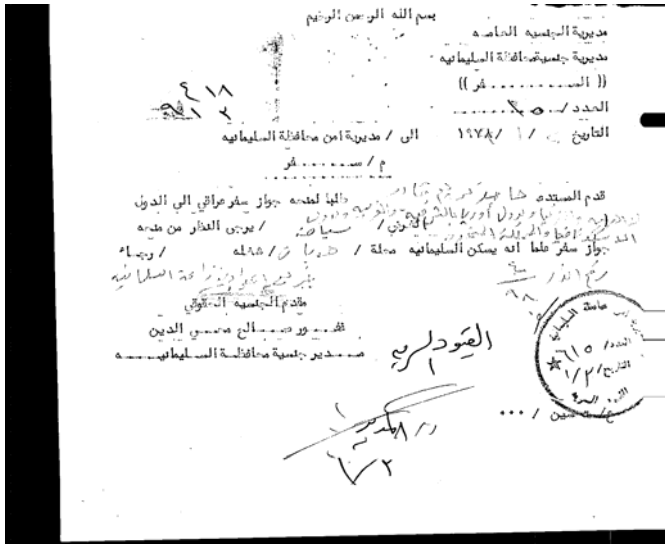
Е. Д. Ильютченко

Лицензия продлена до «__» _____ 200_ г.

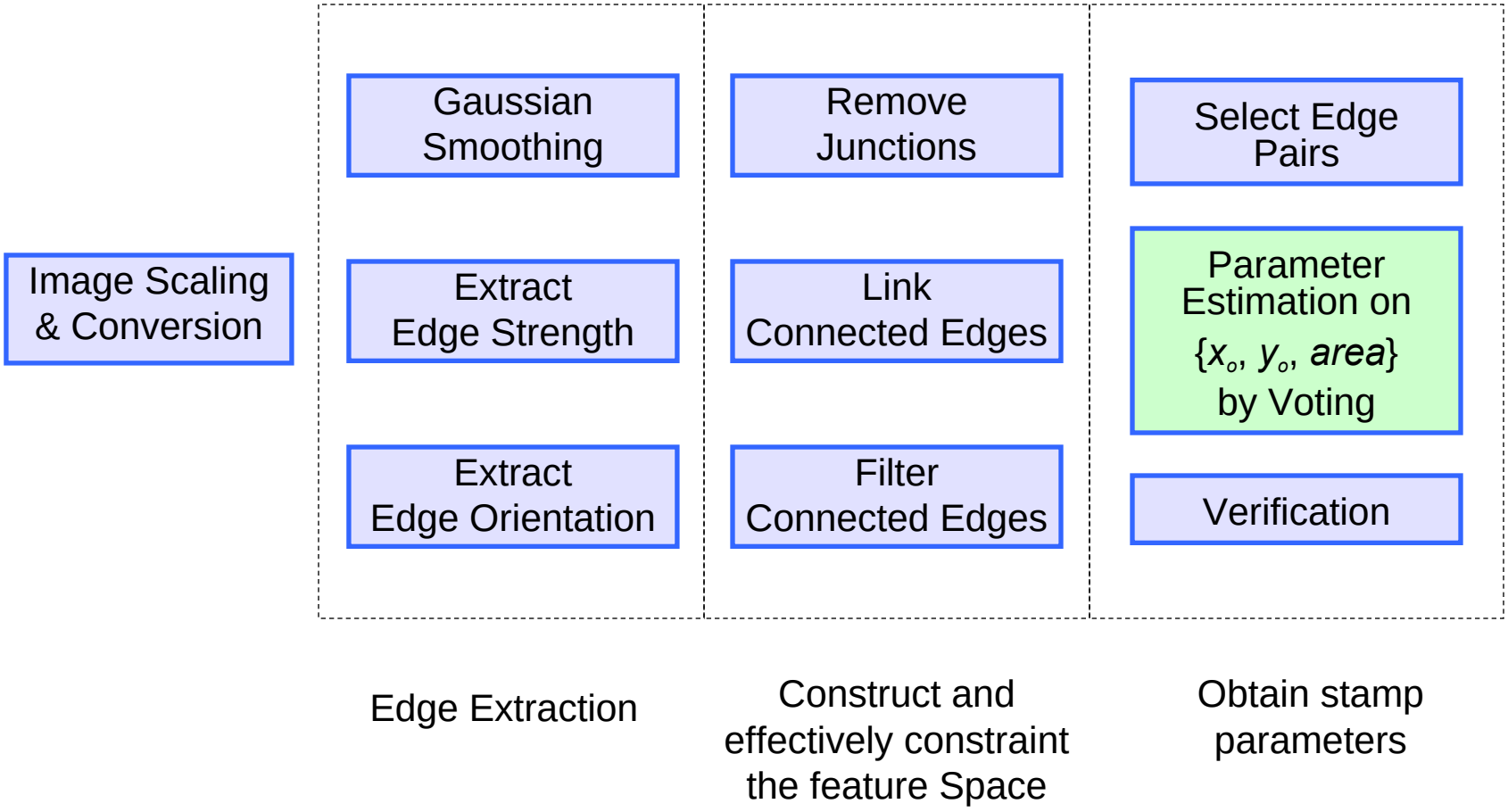
Motivations

- Treat stamps as regions with analytic shaped contours in noisy documents
  - Majority of stamps in our Arabic document databases are elliptic or circular objects
  - Shape distortions due to a variety of factors alter the eccentricity of the object, making even a perfect circle elliptic
- Our proposed stamp detection framework is based on recognizing strongly connected edge patterns
- Adopt the Hough transform voting scheme through an efficient ellipse parameterization





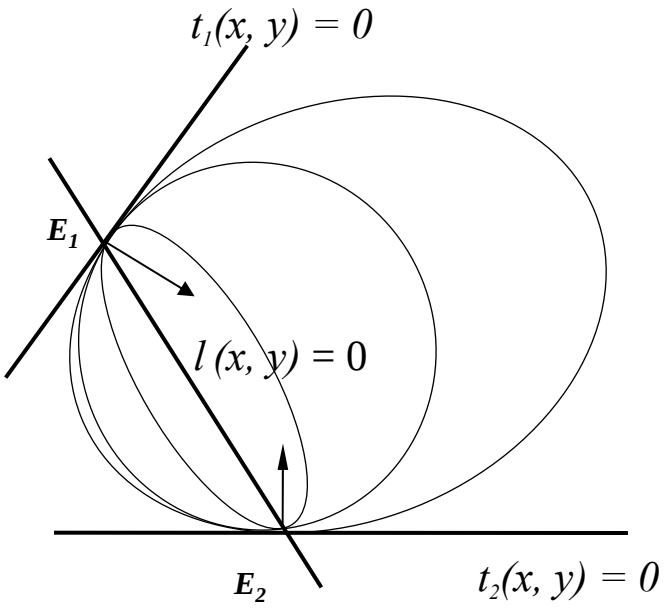
Our stamp detection approach



Traditional ellipse detection techniques

- Approaches based on Hough transform (HT) and its variants [2-6], RANSAC [7], and fuzzy logic [8-9] generally need to map sets of feature points to a parameter space
  - Obtaining the five parameters $\{x_o, y_o, a, b, \theta\}$ of an ellipse is computationally demanding
  - This parameterization is also inefficient as in many real problems, we only need to know a subset of these five parameters – e.g. $\{x_o, y_o, area\}$
- Other approaches including least-square fitting [10] and genetic algorithm [11] require pre-processing and are not robust against outliers/occlusions and noise

Ellipse detection method using pairs of edges



Tangent line passing E_1:

$$t_1(x, y) \equiv p_1(x - x_1) + q_1(y - y_1) = 0$$

Tangent line passing E_2:

$$t_2(x, y) \equiv p_2(x - x_2) + q_2(y - y_2) = 0$$

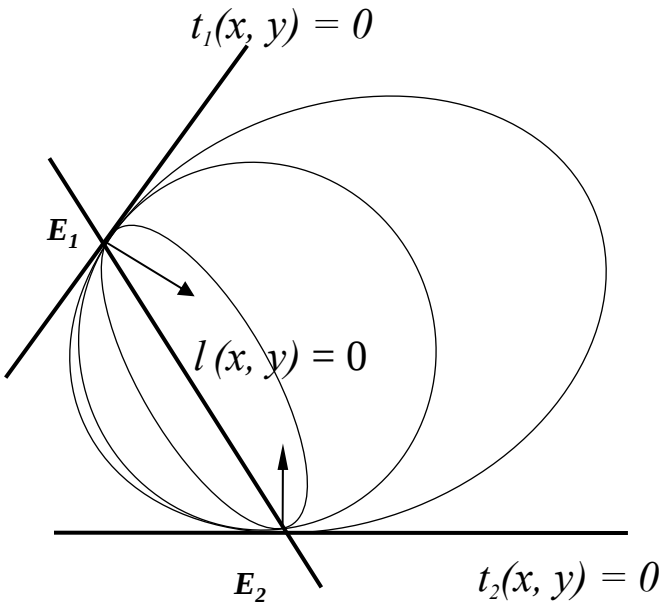
Line E_1E_2:

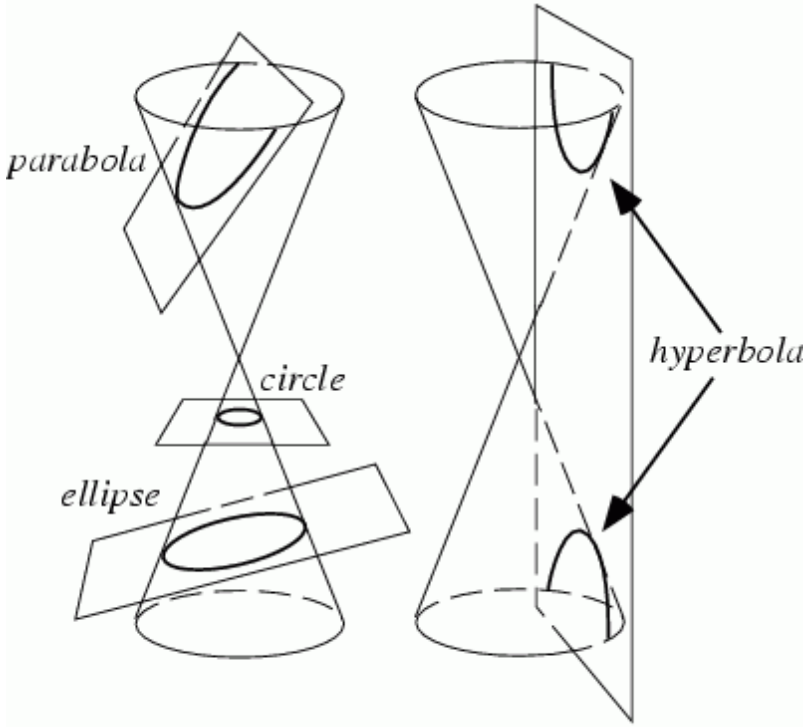
$$l\,(x, y) \equiv (y_1 - y_2)x + (x_2 - x_1)y + x_1y_2 - x_2y_1 = 0$$

Define a quadratic function $f(x, y)$ as

$$f(x, y) \equiv l^2(x, y) - \lambda t_1(x, y)t_2(x, y) = 0 \qquad (1)$$

Ellipse detection method using pairs of edges





The quadratic function $f(x, y)$ represents the family of 2nd-order curves that pass points E_1 and E_2 and tangent to lines $t_1(x, y)$ and $t_2(x, y)$.

Ellipse detection method using pairs of edges

- We can rewrite the quadratic function $f(x, y)$ in the canonical form of (2)

$$f(x,y) \equiv l^2(x,y) - \lambda t_1(x,y)t_2(x,y) = 0$$
$$= ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0 \qquad (2)$$

- For any two connected edges, i.e. for a given set of $\{(x_1, y_1), (x_2, y_2), (p_1, q_1), (p_2, q_2)\}$, parameters a, b, c, f, g, h in equation (2) above can be simply mapped as first-order linear functions in λ.

Ellipse detection method using pairs of edges

$$a(\lambda) = (y_1 - y_2)^2 - \lambda p_1 p_2$$

$$b(\lambda) = (x_2 - x_1)^2 - \lambda q_1 q_2$$

$$c(\lambda) = (x_1 y_2 - x_2 y_1)^2 - \lambda (p_1 x_1 + q_1 y_1)(p_2 x_2 + q_2 y_2)$$

$$f(\lambda) = (x_1 y_2 - x_2 y_1)(x_2 - x_1) + \lambda [q_1 (p_2 x_2 + q_2 y_2) + q_2 (p_1 x_1 + q_1 y_1)]/2$$

$$g(\lambda) = (x_1 y_2 - x_2 y_1)(y_1 - y_2) + \lambda [p_1 (p_2 x_2 + q_2 y_2) + p_2 (p_1 x_1 + q_1 y_1)]/2$$

$$h(\lambda) = (y_1 - y_2)(x_2 - x_1) - \lambda (p_1 q_2 + p_2 q_1)/2$$

- For a given pair of edges with their respective gradient directions, the ellipse is uniquely parameterized by only one parameter λ.

Ellipse detection method using pairs of edges

- The center of the ellipse is given by:

$$x_o(\lambda) = \frac{h(\lambda)f(\lambda) - b(\lambda)g(\lambda)}{a(\lambda)b(\lambda) - h^2(\lambda)}$$

$$y_o(\lambda) = \frac{h(\lambda)g(\lambda) - a(\lambda)f(\lambda)}{a(\lambda)b(\lambda) - h^2(\lambda)}$$

- The area of the ellipse can be derived as [12]:

$$Area(\lambda) = \frac{\pi \mid d(\lambda) \mid}{\sqrt{a(\lambda)b(\lambda) - h^2(\lambda)}}$$

where

$$d(\lambda) = \frac{a(\lambda)f^2(\lambda) + b(\lambda)g^2(\lambda) - 2f(\lambda)g(\lambda)h(\lambda)}{a(\lambda)b(\lambda) - h^2(\lambda)} - c(\lambda)$$

Reduce search space for parameter λ

- The set of distinct value λ can also be effectively bounded by considering its range that corresponds to ellipses in the quadratic function $f(x, y)$.

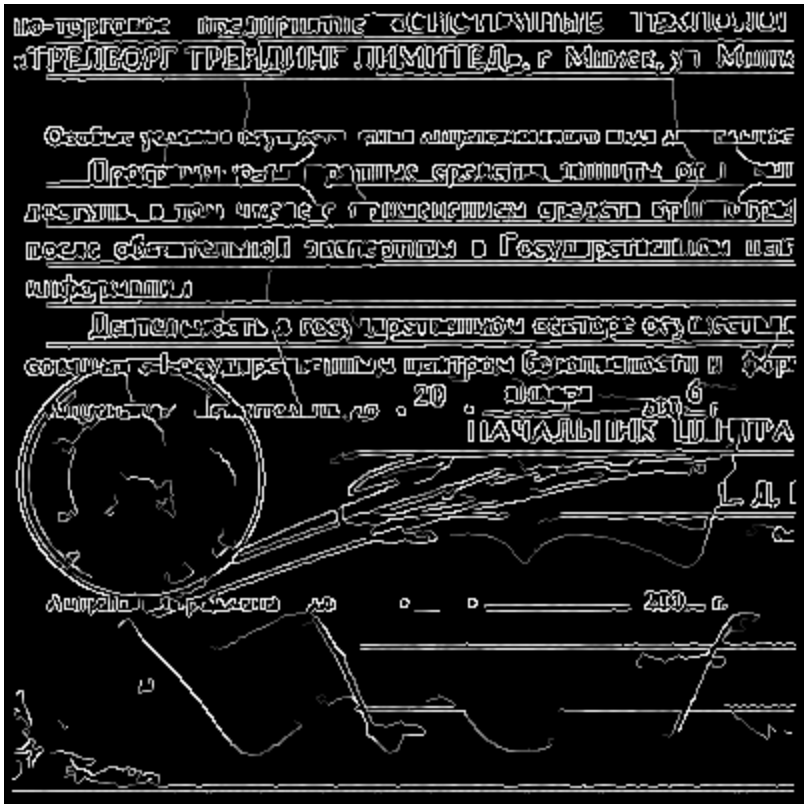
- The range of meaningful λ value that corresponds to ellipses is given by [13]

$$0 < \lambda < \frac{4[p_1(x_2 - x_1) + q_1(y_2 - y_1)][p_2(x_1 - x_2) + q_2(y_1 - y_2)]}{(p_1 q_2 - p_2 q_1)^2}$$

Computational complexity

- Let D be the number of distinct values in one dimensional parameter space and E the number of selected edge points
- Classic Hough transform based ellipse detection [14] runs in $O(ED^3)$, using orientation information of single edge points
- Our approach exploits the first-order derivative (gradient) of a pair of edges, which reduces the running time from $O(ED^3)$ to $O(E^2D)$
- Since we consider only those edge pairs that are from the same connected component of finite bounded length, further reducing the computation from $O(E^2D)$ to $O(ED)$

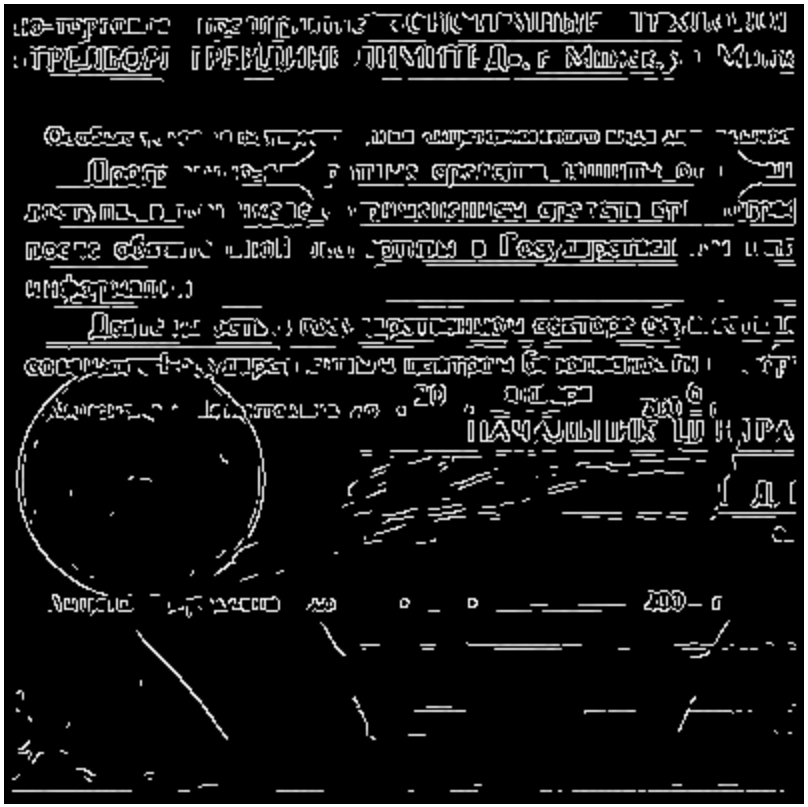
Demo



Region of a sample image

Strength of edge gradient

Demo



Strong edges

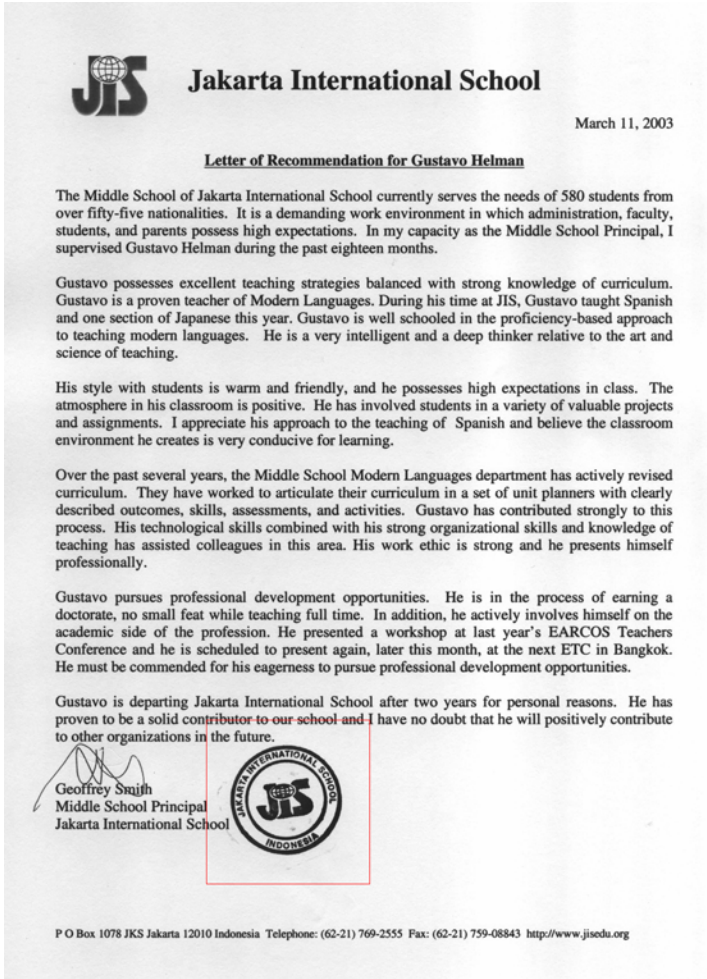
Orientation of edge gradient

Demo

Top 10 candidates in the 3-D parameter space in ellipse center and area, i.e. (x_o, y_o, *area*)

(68, 238, 11313), score = [5485509]
(56, 202, 6464), score = [501958]
(52, 226, 8080), score = [431456]
(72, 206, 8080), score = [352608]
(84, 266, 6464), score = [278291]
(84, 210, 6464), score = [260775]
(44, 222, 8080), score = [247448]
(28, 270, 3232), score = [241991]
(40, 202, 4848), score = [224263]
(76, 230, 9696), score = [215384]

Demo



Jakarta International School

March 11, 2003

Letter of Recommendation for Gustavo Helman

The Middle School of Jakarta International School currently serves the needs of 580 students from over fifty-five nationalities. It is a demanding work environment in which administration, faculty, students, and parents possess high expectations. In my capacity as the Middle School Principal, I supervised Gustavo Helman during the past eighteen months.

Gustavo possesses excellent teaching strategies balanced with strong knowledge of curriculum. Gustavo is a proven teacher of Modern Languages. During his time at JIS, Gustavo taught Spanish and one section of Japanese this year. Gustavo is well schooled in the proficiency-based approach to teaching modern languages. He is a very intelligent and a deep thinker relative to the art and science of teaching.

His style with students is warm and friendly, and he possesses high expectations in class. The atmosphere in his classroom is positive. He has involved students in a variety of valuable projects and assignments. I appreciate his approach to the teaching of Spanish and believe the classroom environment he creates is very conducive for learning.

Over the past several years, the Middle School Modern Languages department has actively revised curriculum. They have worked to articulate their curriculum in a set of unit planners with clearly described outcomes, skills, assessments, and activities. Gustavo has contributed strongly to this process. His technological skills combined with his strong organizational skills and knowledge of teaching has assisted colleagues in this area. His work ethic is strong and he presents himself professionally.

Gustavo pursues professional development opportunities. He is in the process of earning a doctorate, no small feat while teaching full time. In addition, he actively involves himself on the academic side of the profession. He presented a workshop at last year's EARCOS Teachers Conference and he is scheduled to present again, later this month, at the next ETC in Bangkok. He must be commended for his eagerness to pursue professional development opportunities.

Gustavo is departing Jakarta International School after two years for personal reasons. He has proven to be a solid contributor to our school and I have no doubt that he will positively contribute to other organizations in the future.

Geoffrey Smith
Middle School Principal
Jakarta International School

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证书编号：深 R-2003-0274

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二00三年 月 日

2003 11 25

Demo

Do you have handwritten notes ?

… and don't need them anymore?

Well, bring them to us – we pay for it!

The Language and Media Processing Laboratory (LAMP) is collecting handwritten notes or annotations from classes, lectures, conferences, workshops, etc. for research in document image analysis. We are searching for notes written in the following scripts:

Arabic, Armenian, Burmese, Chinese, Cyrillic, Devanagari, Ethiopic, Greek, Hebrew, Japanese, Korean, and Thai.

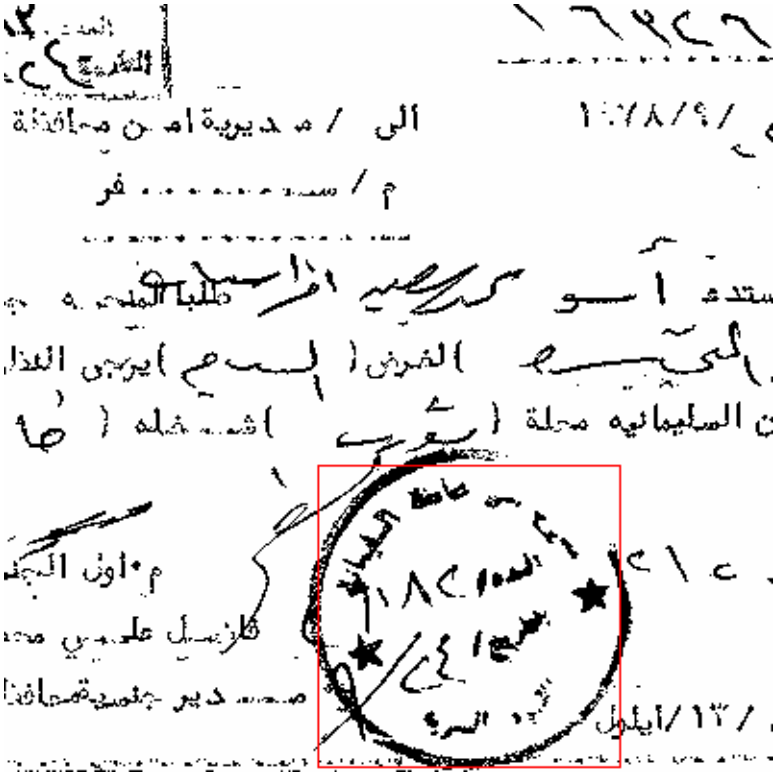
Your notes may contain diagrams, tables, equations, and figures. Printed documents with a significant amount of handwritten annotations are also useful for us. However, the documents should not contain any personal information or names of individuals.

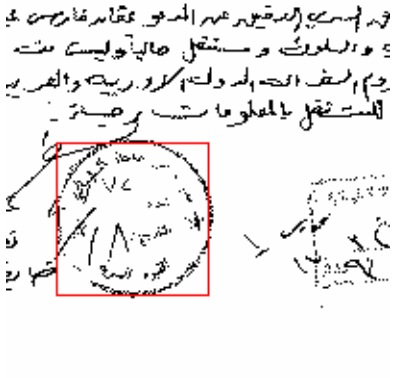
Since we have different needs for each script and also upper limits as to how many pages a writer can provide, you may contact us or send us some samples in advance to see if your data meets our requirements. If it does, you will receive **$5.00 for every 10 pages** you provide by simply handing over your notes and allowing us to use them for our research. We would also pay the shipping charges for sending handwritten notes to us from friends in your home country.

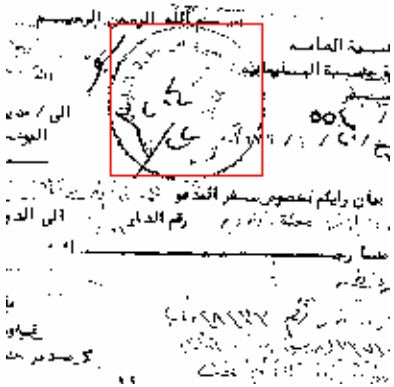
Contact:

Dr. Stefan Jaeger, Dr. David Doermann
Laboratory for Language and Media Processing (LAMP)
3453 A.V. Williams Building, University of Maryland, College Park
Phone: 301-405-0125 or 1767
Email: {jaeger, doermann}@umiacs.umd.edu

Demo

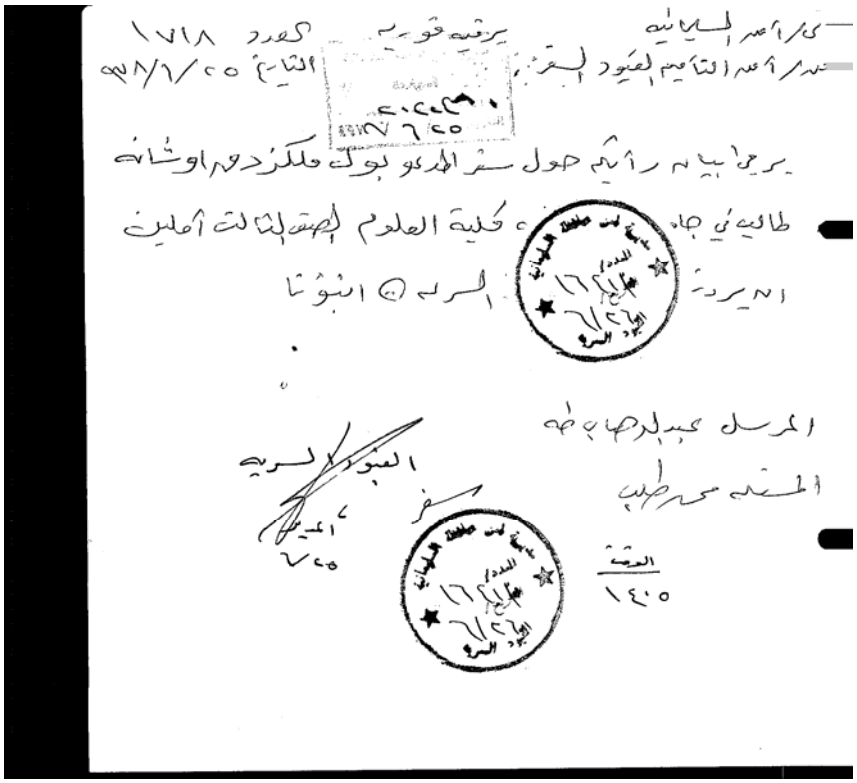


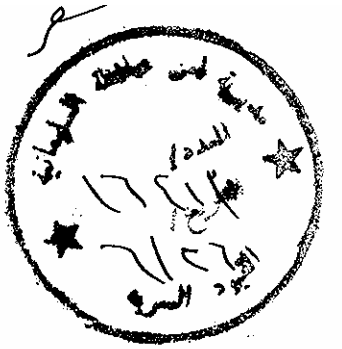




Demo

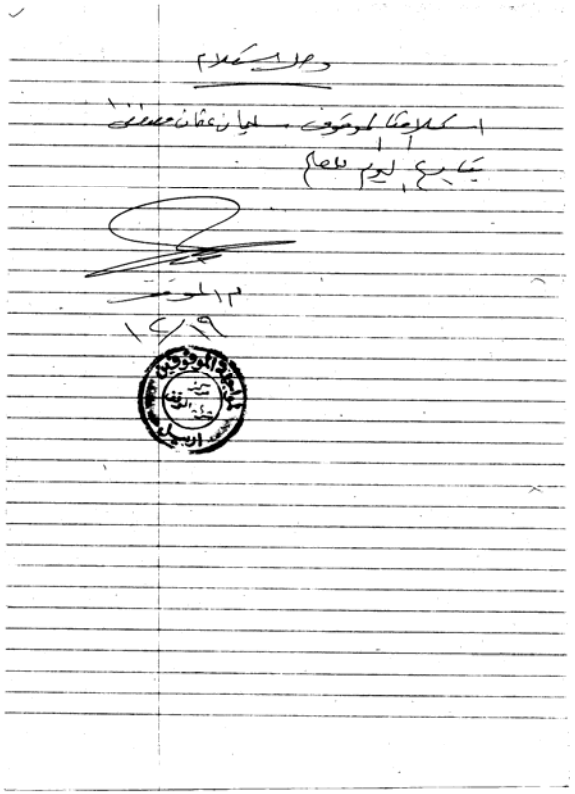
Capability to detect multiple stamp instances

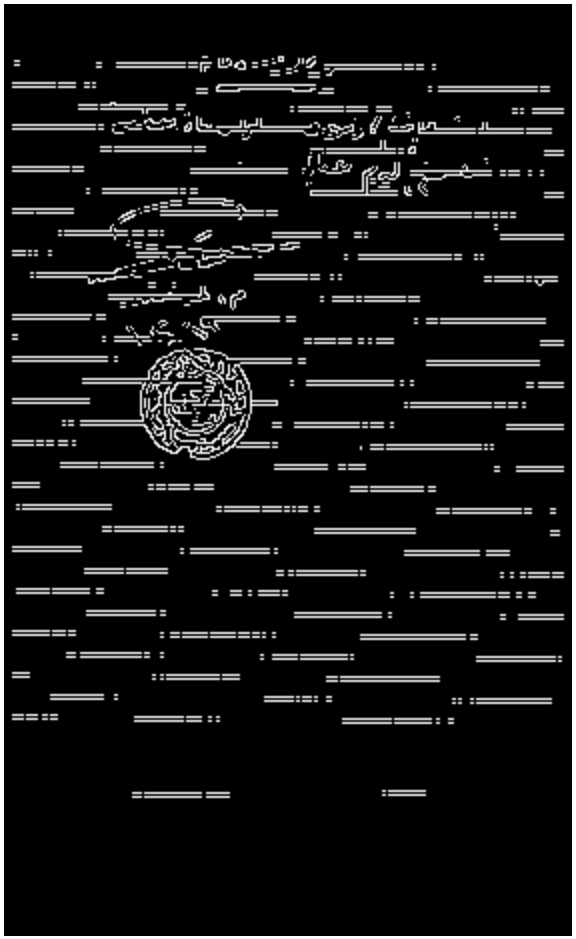




Demo

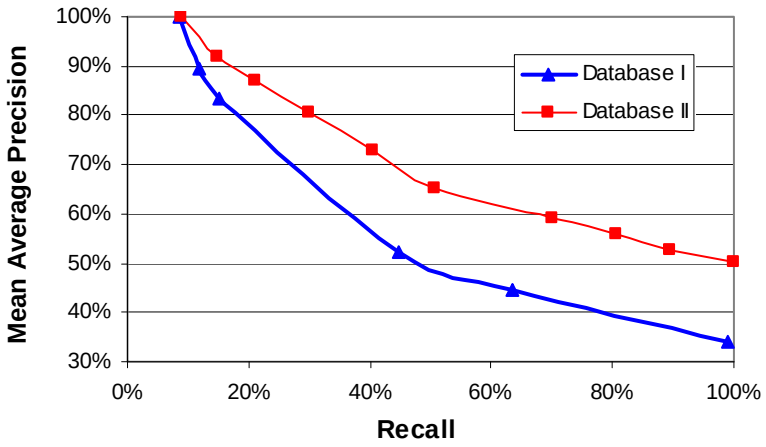
Capability to detect stamp instances in diverse backgrounds





Experiment

Test Databases	Total Images	Images with The Retrieved Stamp
Database 1	436	92 (Circular)
Database 2	193	68 (Elliptic)



Conclusion

- The stamp detector proves to be robust against outliers and occlusions in degraded documents using only limited a priori information
- The speed of detection is 2-3 seconds on 2000×2500 pixel images. Improvements can reduce the running time further by carefully constraining the feature space
- Production retrieval tests on real Arabic document databases, each with about 5000 binary images.
- It can be used as real-time ellipse detector in video
- We are also working on robust techniques that are able to achieve auto recognition of logos/stamps

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