

# Sabancı-Okan System at ImageClef 2013 Plant Identification Competition

B. Yanıkoğlu<sup>1</sup>, E. Aptoula<sup>2</sup> ve S. Tolga Yıldiran<sup>1</sup>

<sup>1</sup>Sabancı University

<sup>2</sup>Okan University

Istanbul, Turkey

- **Task:** Recognize the plant in agiven image
- **Motivation:**
  - An online content-based plant search engine
  - A tool for assisting botanists
  - A mobile application for recognizing edible plants or avoiding hazardous ones
  - ...



## A standard object recognition problem?



- **Lighting, pose, scale, color variations + ...**
- Seasonal color variations
- Leaf shape variations due to plant age
- Leaf/Flower composition variations

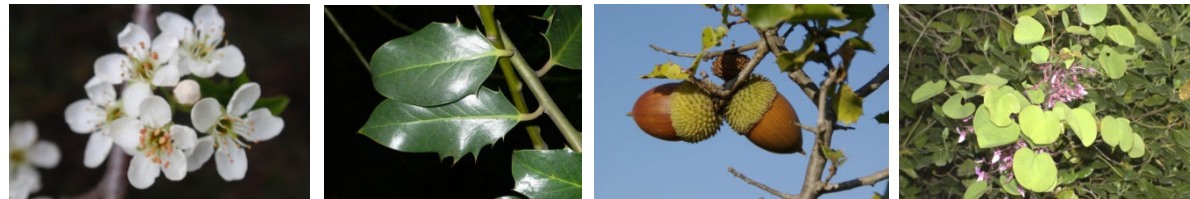
Scanned &  
Simply  
Photographed  
Leaves  
(Scan & Scan-like)

SheetAsBackground



Partial or Full  
Plant  
Photographs  
on Natural BG.  
(Photos)

NaturalBackground





# Sabancı-Okan Collaboration

- Erchan Aptoula, Okan University
  - Expertise: Mathematical morphology
  - Main roles: Segmentation, Feature Extraction
- Berrin Yanikoglu, Sabanci University
  - Expertise: Object recognition (biometrics, handwriting recognition)
  - Main role: Feature Extraction, Classifiers
- Students: Caglar Tirkaz, Tolga Yildiran
  - Main role: System building
- We typically work for one month for ImageCLEF





Our collaboration has so far achieved:

- 4th place overall in 2011 (70 species, ~5,500 samples)
- **1st place overall in 2012** (126 species, ~12,000 samples) **in both automated and human assisted categories**
- **1st place in 2013** (250 species, ~26,000 samples) **with simple background images** (*SheetAsBackGround*)

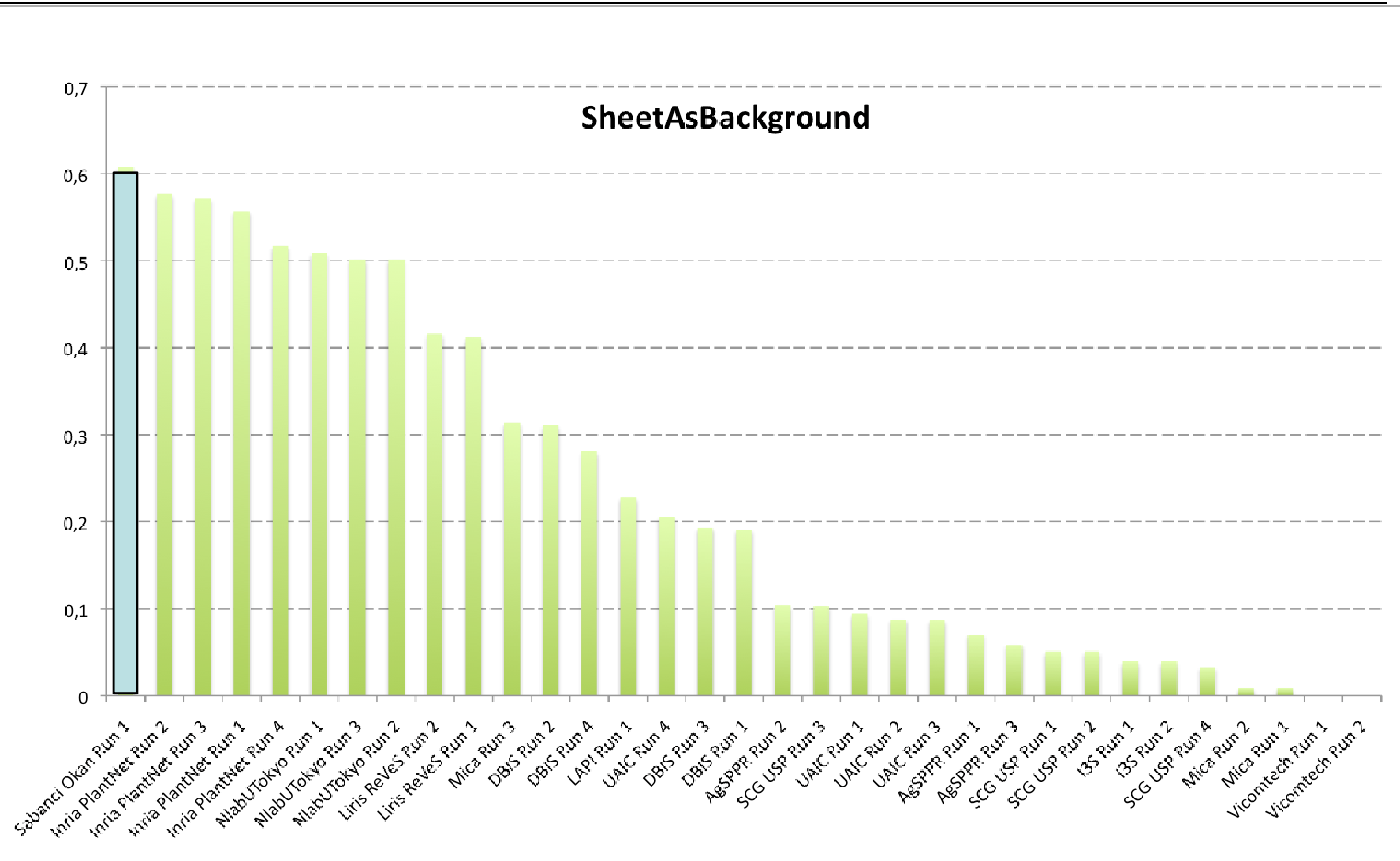
## ImageCLEF 2012 Plant Identification Competition Results

Group	Scan	Scan-Like	Photograph	Score
Sabancı-Okan run 1 [YANIKOGLU 2012]	<b>0.58 (1.)</b>	0.55	0.16	<b>0.43 (1.)</b>
INRIA-Imedia PlantNet run1 [BAKIC 2012]	0.49	0.54	0.22	0.42
INRIA-Imedia PlantNet run2 [BAKIC 2012]	0.39	<b>0.59 (1.)</b>	0.21	0.40
LSIS-DYNI run 3 [PARIS 2012]	0.41	0.42	<b>0.32 (1.)</b>	0.38
ARTELAB run 1 [GALLO, 2012]	0.40	0.37	0.14	0.30
Zhao/HFUT run 3 [ZENG, 2012]	0.32	0.26	0.11	0.23
BTU DBIS run 2 [BÖTTCHER, 2012].	0.27	0.17	0.17	0.21
IFSC/USP run 3 [CASANOVA 2012]	0.20	0.14	0.12	0.16

## ImageCLEF 2013 Plant Identification Competition Results

Group	Scan and Scan-Like	Natural Background
Sabancı-Okan Run 1	<b>0.607 (1.)</b>	0.181 (3.)
Inria PlantNet Run 1	0.577 (2.)	0.385 (2.)
Nlab Univ. Of Tokyo Run 3	0.502 (3.)	<b>0.393 (1.)</b>
Mica Run 3	0.314 (3.)	0.042 (9.)
DBIS Run 2	0.311 (4.)	0.159 (4.)
...	...	...







- **Segmentation:**

- Morphological top-hat by reconstruction with a very large structuring element (edge preserving filter for uneven illumination correction)
- Area based attribute filter (for noise and artifact removal)
- Quasi-flat zone based simplification (basic level aggregation of spectrally similar pixels)
- Adaptive threshold for binarization
- Post-processing: preserve the largest CC, make sure the foreground contains the object of interest, fill holes.

- **Preprocessing:**

- Image height normalized to 600 pix, preserving aspect ratio



8408.png



21333.png



29318.png



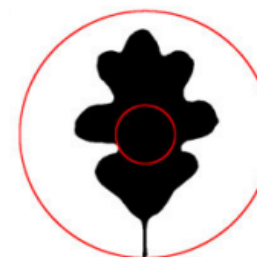
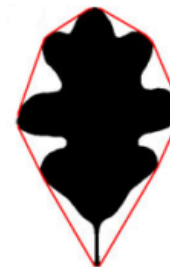
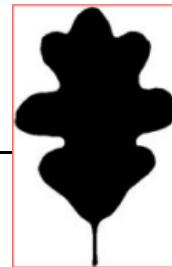
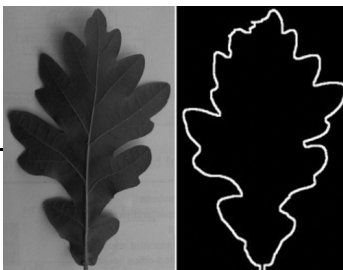
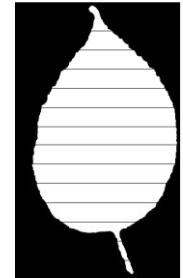
2277.png



6075.png

Feature Group	Feature	Comment
Shape	Fourier Descriptors; Basic Geometrical Features (area, convexity,...); Moment invariants	Rich set including both contour and area-based descriptors
Texture	Gabor filters; Local Binary Patterns; Color morphological covariance	Rich set containing complementary and/or alternative descriptors
Color	Color auto-correlogram; Saturation-weighted hue histogram	Two basic features only. Needs more work.
Local Invariants	Dense SIFT	Not used in the final system, due to shortage of time

- **Fourier Descriptors (50-dim.)**
- **Area Width Factor (10-dim.)**
  - The normalized area of the horizontal strips of the leaf
- **Regional Moments (7-dim.)**
- **Basic Shape Statistics (4-dim.)**
  - {mean,min,max, stdev,...} of contour points' distance to the centroid
- **Angle Code Histogram (10-dim.)**
  - Normalized histogram of the angles between 3 successive points on the contour.
- **Perimeter Convexity (1-dim.)**
  - Ratio of the perimeter of the convex hull, to contour length
- ...





- **Orientation Histograms:**
  - Distribution histogram of subquantized gradient orientations.
- **Circular Covariance Histogram\***
  - A rotation and illumination invariant morphological texture descriptor describing periodicity.
- **Rotation Invariant Point Triplets\***
  - A rotation invariant morphological texture descriptor, describing roughness and granularity.
- **Gabor Filters**
  - Average response to Gabor filters in each of the 8 directions

---

\*) E. Aptoula, *Extending Morphological Covariance*, *Pattern Recognition*, 45(12), 2012.



## Feature Effectiveness

Feature Name	Length	Cross-Val. Acc. %	Val. Acc. %
Orientation Histogram	6	38.81	34.64
Circular Covariance Histogram	24	-	28.26
Rotation Invariant Point Triplets	24	-	17.50
Gabor features	8	26.26	15.60

- **Color auto-correlogram** (252-dim.) describes the spatial correlation of colors.
  - It is computed in the LSH color space after a non-uniform quantization to 63 colors (7 levels for hue, 3 for saturation and 3 for luminance).
  - It consists of a 63x4 table where the entry (i; j) denotes the probability of encountering two pixels of color i at a distance of j pixels for (1,3,5, or 7 pixels) .
- **Saturation-weighted hue histogram**
  - $W_\theta$  for  $\theta \in [0; 360]$  is calculated as:  
where  $H_x$  and  $S_x$  are the hue and saturation values  
 $\delta_{ij}$  is the Kronecker delta function.

$$W_\theta = \sum_x S_x \delta_{\theta H_x}$$

Used in NaturalBackground photos only.

- **Development-Validation Sets Partition:**

- **Try to reduce overfitting:** For all species, if there are more than one individual plant in its images, then all of the images of that individual plant is used for validation and all other are used for training.

Category	Development	Validation
SheetAsBackground (Isolated leaves)	7,867	1914
NaturalBackground (Unconstrained photos)	7,865	2,562
Flower	2,325	1197
Entire	1,455	594
Fruit	960	495
Stem	1,045	276
All	15,732	4,476

- **Dataset:**

- Used only the development images of a class for the recognizer trained for that class.

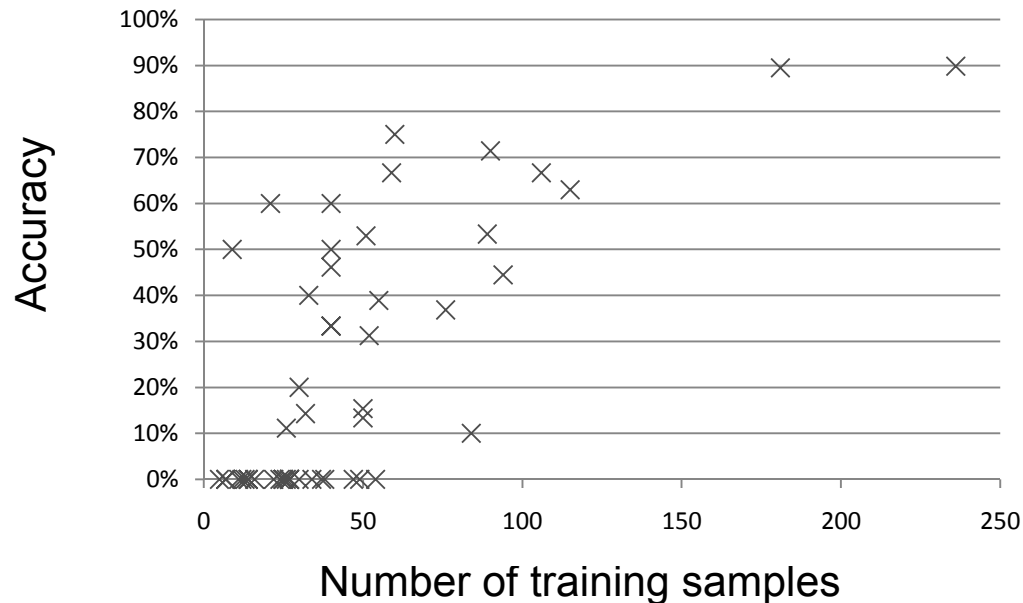


- **Base Classifier:**
  - Support Vector Machines:
    - SMO optimization on Weka, with 2nd degree polynomial kernel.
    - Low soft penalty (C) value to reduce overfitting

Table 3: Cross-validation and validation set accuracies, along with the official test scores obtained by our system.

Category	Features	Cross-Val.	Validation	Inverse Rank
UniformBackground	Shape, texture	93.77%	70.64%	0.607
NaturalBackground				0.181
Flower	Texture, color, month	40.20%	34.50%	0.223
Fruit	Texture, color, month	51.33%	43.64%	0.194
Entire	Texture, color, month	34.23%	29.50%	0.174
Stem	Texture	-	9.30%	0.106
Leaf	Shape, texture	-	-	0.049

- Accuracy increases with number of training samples



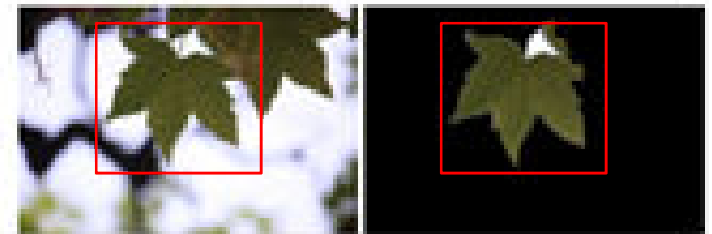
- Accuracy is lower for multi-leaflet plants
  - Often, the confused class is also a multi-leaflet plant
- Overfitting is a problem
  - Classifier combination techniques may help



To recognize photographs, we adopt these three complementary approaches that may be more suitable with different images:

1. **Single leaf segmentation and recognition (2012)**

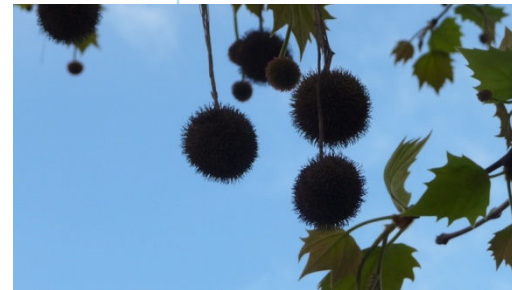
- to leverage our expertise in isolated leaf recognition and as a complementary method to local invariants.



2. **Globally extracted features (2013)**

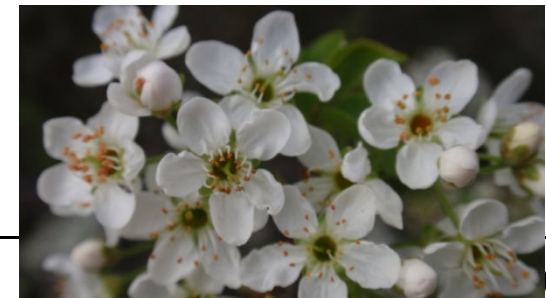
(color, texture and month)

- Surprisingly good despite using little information



3. **Local invariants (2013, but not in the final system)**

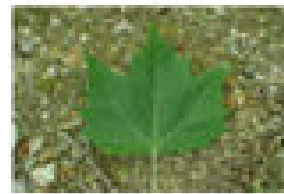
- Avoids segmentation and is found successful in other systems



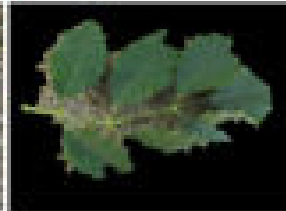
# Recognizing Photographs from a Single Leaf Current Performance



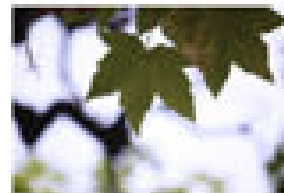
(a)



(b)



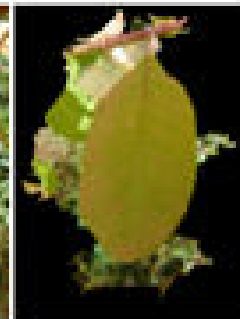
(c)



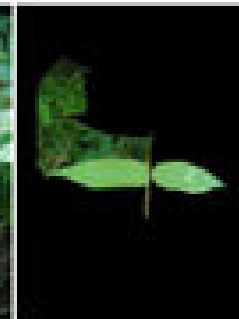
(d)



(e)

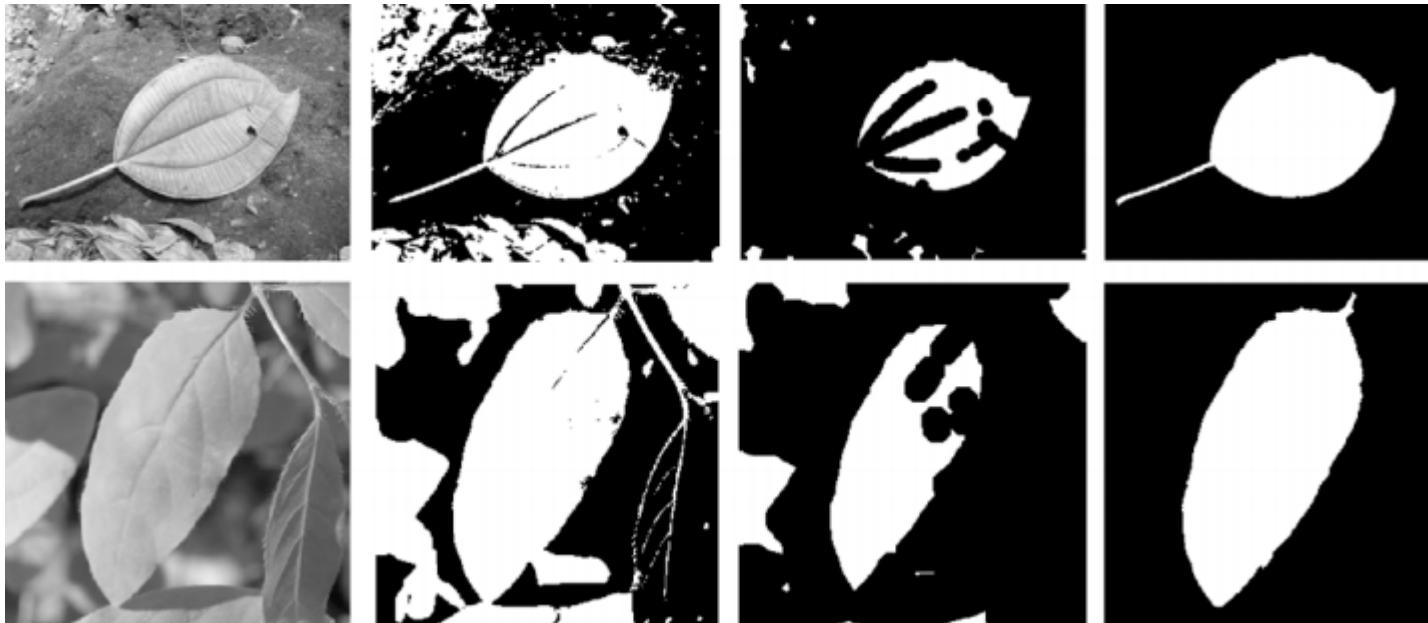


(f)



(g)

- Based on Otsu's algorithm (2011)
- Based on quasi-flat regions and watershed transform (2012)
  - We also used a separate marker-based approach in the human assisted category



- System building
  - Separate classifiers (e.g. For flower, stem etc) are often beneficial but increase the effort
- Long distance collaboration is very useful, but requires effort
  - Exchange codes rather than whole processed data etc.
- Fully general features and approaches are good, but the extra mile is gained through special focus.
  - This is a fun problem.

- **Local invariants** for NaturalBackground photographs
  - SIFT, SURF,...
- Exploit **color** information for leaf recognition
- Combine classifiers to reduce **overfitting**
- Use a **classifier hierarchy** according to image content
  - E.g. For multi-lobe leaves (98.8% success on identifying them)
- ...





- 
- Thank you for listening!
  - Thanks to the ImageCLEF organizers for a well-run lab!
    - Keeping the data and results on the web is great for future comparative work.
  - For any further questions or comments, please email [yanikoglu@gmail.com](mailto:yanikoglu@gmail.com)