



# Bilkent University Computer Engineering Department



## MS and PhD Programs

Prof. Dr. Selim Aksoy

# Research Areas

- Algorithms
- Artificial intelligence
- Big data
- Bioinformatics
- Cloud computing
- Computational biology
- Computational geometry
- Computer architecture
- Computer graphics
- Computer networks
- Computer vision
- Cryptography
- Data mining
- Data science
- Data security
- Database systems
- Graph visualization
- High performance computing
- Image analysis
- Information retrieval
- Machine learning
- Mobile systems
- Parallel and distributed systems
- Pattern recognition
- Robotics
- Scientific computing
- Software engineering
- Virtual reality

# Applications

- **Application Deadlines:**
  - March 31, 2023 (early-bird deadline)
  - May 31, 2023 (regular deadline)
- **Online Application:**
  - <https://stars.bilkent.edu.tr/gradapp/>
- **Requirements for application:**
  - CGPA  $\geq 2.80 / 4.00$
  - ALES (Turkish citizens) or GRE (Foreign applicants)
    - ALES: Quantitative  $\geq 55$  (for MS), 80 (for PhD w/o BS)
    - GRE: Quantitative  $\geq 153$  (MS), 157 (PhD)
  - English Proficiency: TOEFL (IBT)  $\geq 87$  or IELTS avg  $\geq 6.5$  (and min 5.5 in each section)
  - And YDS  $\geq 55$  (for Turkish citizen applying PhD).

# Interview

- Date: we will inform applicants about interview dates
- If not uploaded during online application, documents need to be submitted during interview:
  - Transcript
  - ALES or GRE score report
  - Proof of English Proficiency  
(TOFLE, IELTS or YDS report)



# Acceptance Requirements

- Grad committee approval
- At least one faculty member willing to work with the applicant towards thesis
- Passing the interview and department approval
- Graduate School of Engineering and Science approval

# Scholarship Options

- Department scholarship
  - Tuition waiver (100%)
  - Stipend (paid by Department)
  - Eligibility for accommodation in dormitories or University housing
  - Health Insurance
  - Office (shared)
  - Meal Card support (for Ph.D. students)

# Scholarship Options

- TÜBİTAK scholarship or TÜBİTAK projects
  - Tuition waiver (100%)
  - Stipend (paid by TÜBİTAK and Department)
  - Eligibility for accommodation in dormitories or University housing
  - Health Insurance
  - Office (shared)
  - Meal Card support (for Ph.D. students)

# Scholarship Options

- Project grants (other than TÜBİTAK projects)
  - Tuition waiver (100%)
  - Stipend (paid from the project budget and Department)
  - Eligibility for accommodation in dormitories or University housing
  - Health Insurance
  - Office (shared)
  - Meal Card support (for Ph.D. students)
- Graduate School scholarship
  - Tuition waiver (between 80% - 100%)

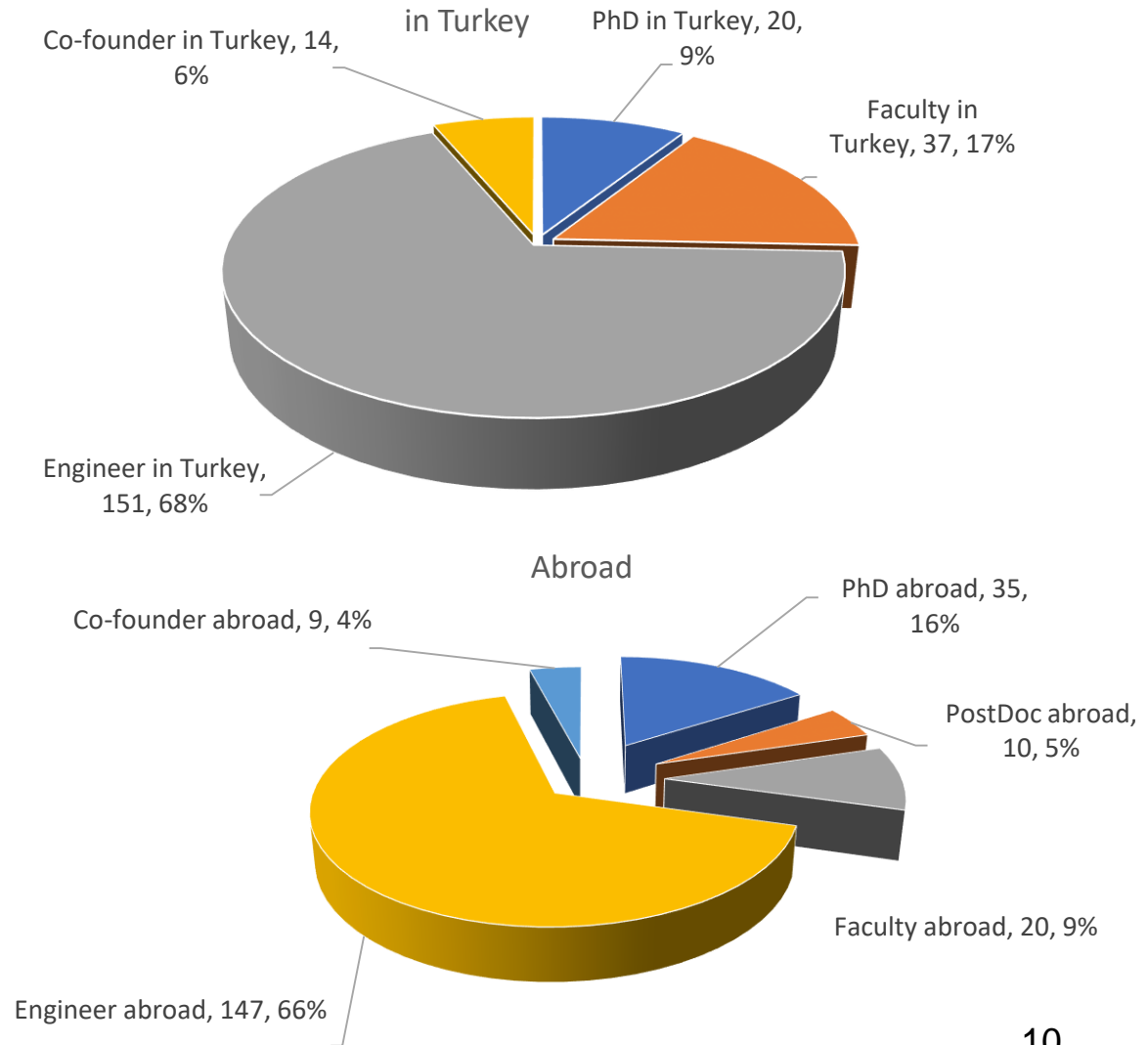
# Degree Requirements

- MS
  - 7 technical elective courses + Seminar + MS Thesis + Research Methods and Academic Publication Ethics course
- PhD
  - 7 technical elective courses + Seminar + Qual Exam + PhD Thesis + Journal Publication + Research Methods and Academic Publication Ethics course

# Graduates of MS Program

Position	Count	%
PhD in Turkey	20	9.0%
Faculty in Turkey	37	16.7%
Engineer in Turkey	151	68.0%
Co-founder in Turkey	14	6.3%
PhD abroad	35	15.8%
PostDoc abroad	10	4.5%
Faculty abroad	20	9.0%
Engineer abroad	147	30.6%
Co-founder abroad	9	4.1%
Unknown	37	7.7%

In Turkey	222	46.3%
Abroad	221	46.0%
Unknown	37	7.7%
Total:	480	100.0%



# Graduates of MS Program

## in Turkey

Bilkent Univ.	25
ASELSAN	20
HAVELSAN	16
TÜBİTAK	13
Hacettepe Univ.	6
METU	6
TSK	5
STM	4
TCMB	4
Vestel	4
Cybersoft	3
Garanti Teknoloji	3
MilSOFT	3
OpsGenie	3
Sabancı Univ.	3
Akdeniz Univ.	2
Oracle	2

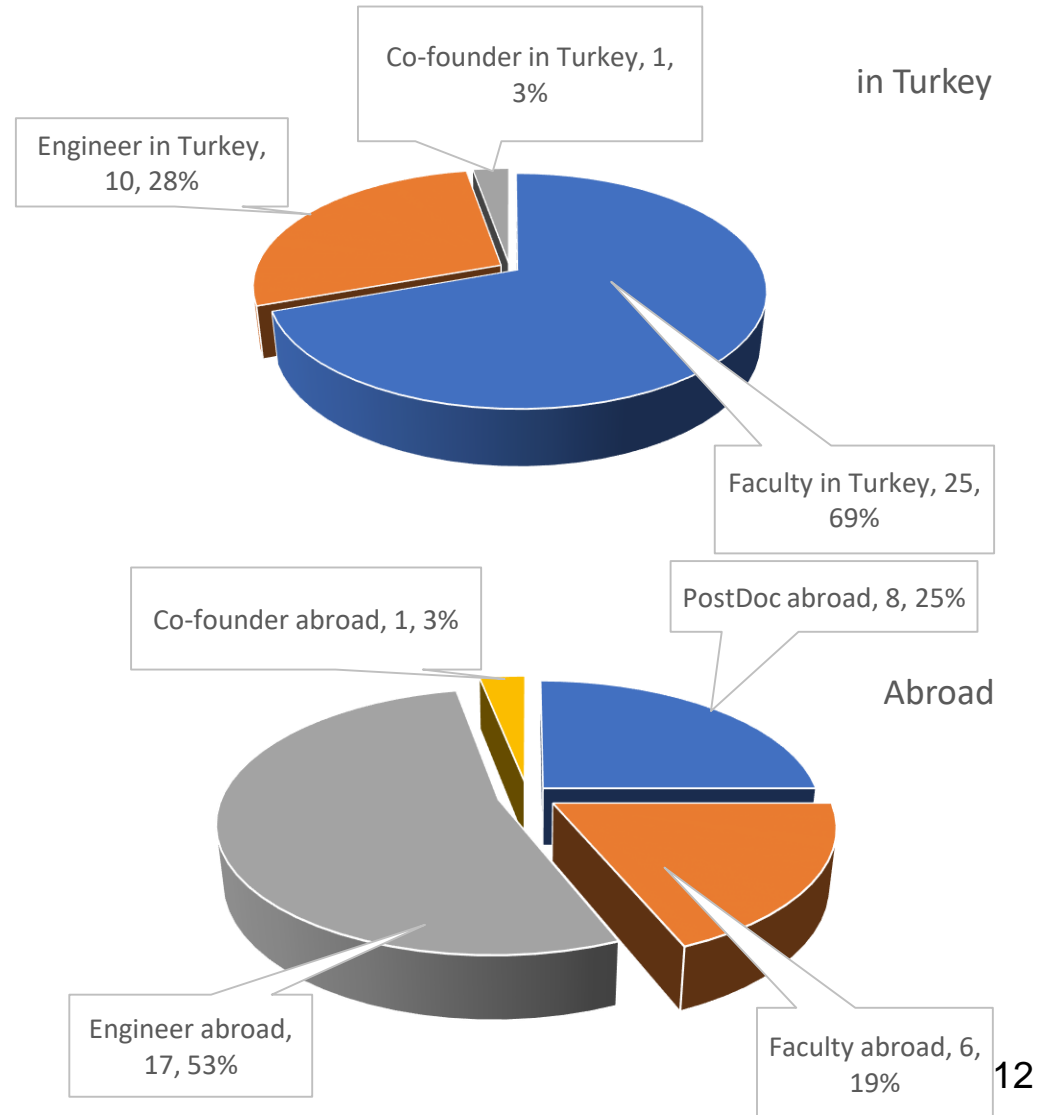
## Abroad

Microsoft	23
Google	16
Amazon	6
Booking.com	4
Case Western Reserve Univ.	4
Facebook	4
Univ. California	4
SAP	3
U. of Massachusetts Amherst	3
UBER	3
EPFL	2
ETH	2
Imperial College	2
Sandia National Labs.	2
U. of Texas at San Antonio	2
University of Florida	2
University of Waterloo	2
U. of Illinois at Urbana-Champaign	1
Washington U. in St. Louis	1

# Graduates of PhD Program

Position	Count	%
Faculty in Turkey	25	69.4%
Engineer in Turkey	10	27.8%
Co-founder in Turkey	1	2.8%
PostDoc abroad	8	25.0%
Faculty abroad	6	18.8%
Engineer abroad	17	53.1%
Co-founder abroad	1	3.1%

In Turkey	36	52.9%
Abroad	32	47.1%
Total:	68	100.0%





# Graduates of PhD Program

## in Turkey

METU	4
Bilkent University	3
Hacettepe Univ.	3
Akdeniz University	2
Sabancı Univ.	3
TED University	2
Ankara University	1
Aselsan	1
Atılım University	1
Beykent University	1
Çukurova Üniversitesi	1
SAP	1
TAI	1
TCMB	1
Turkcell	1

## Abroad

Amazon	3
Oregon Health and Sci. U.	3
Case Western R. U.	2
Lawrence Berkeley Lab	1
LIP ENS-LYON CNRS	1
ETH	1
Facebook	1
Fraunhofer	1
Georgia Tech	1
Google	1
Microsoft	1
Oracle	1
Salesforce	1
Sandia National Labs.	1
Stony Brook University	1
U. of Central Florida	1
Uber	1

## Faculty Members

Georgia Institute of Technology
Oregon Health and Science University
Stony Brook University
University of Calgary
Bilkent University
Akdeniz University
Ankara University
Ankara Yıldırım Beyazıt University
Atatürk University
Atılım University
Beykent University
Celal Bayar University
Çukurova University
Hacettepe University
Konya Food & Agriculture University
METU
Sabancı University
Selçuk University
TED

# Faculty Members

- In alphabetical order

(Please contact them in person for details.)

# Selim Aksoy

saksoy@cs.bilkent.edu.tr

<http://www.cs.bilkent.edu.tr/~saksoy>

Office: EA 422 (4th floor)



## Research interests:

- Computer vision
- Pattern recognition
- Machine learning

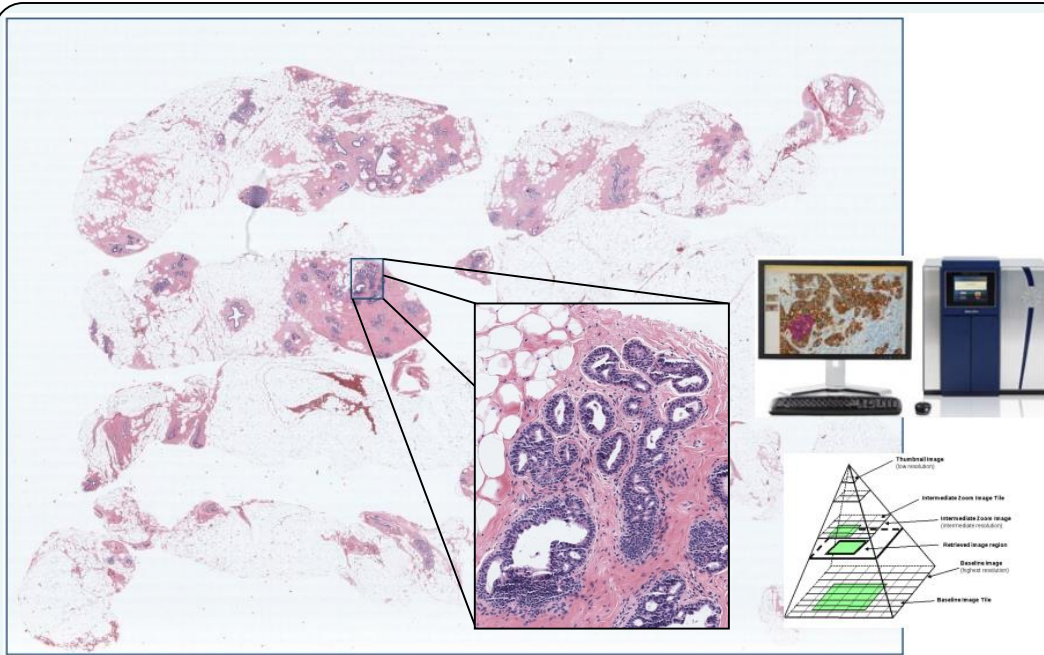
## Current topics:

- Medical image analysis
- Remote sensing image analysis
- Image classification
- Object recognition
- Content-based image retrieval

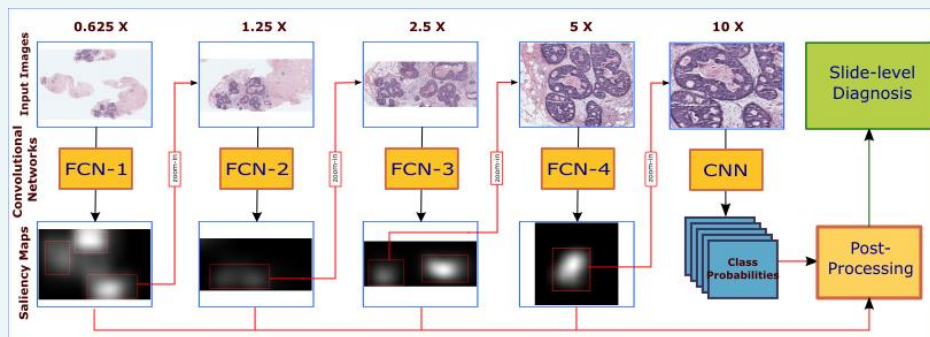
# Sponsored Research Projects

- Medical image analysis
  - TÜBİTAK 1001, 2018-2021
  - TÜBİTAK 1001, 2014-2017
  - TÜBİTAK CAREER Grant, 2005-2010
- Remote sensing image analysis
  - TÜBİTAK 1001, 2010-2012
  - European Commission, Joint Research Centre, 2008-2009
  - TÜBİTAK CAREER Grant, 2005-2010
  - FP6 Marie Curie Grant, 2005-2007
- Image and video mining
  - TÜBİTAK and COST 292 Action, 2004-2008
  - DPT, 2004-2005

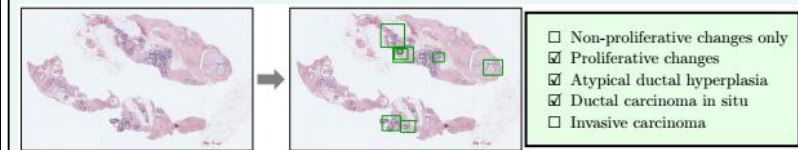
# Medical Image Analysis



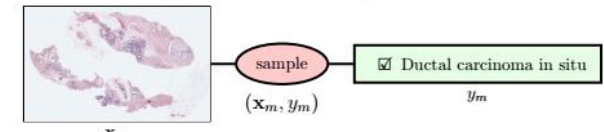
Whole slide image analysis  
(100,000 x 100,000 pixels, 30 GB/image)



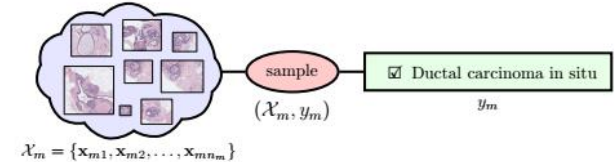
Deep networks for region of interest detection



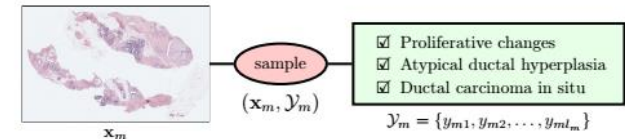
(a) Input to a learning algorithm



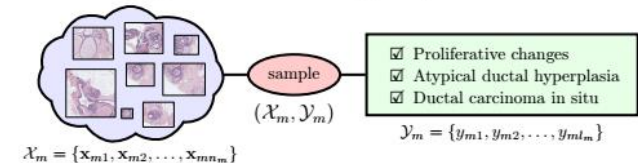
(b) Traditional supervised learning scenario



(c) Multi-instance learning (MIL) scenario



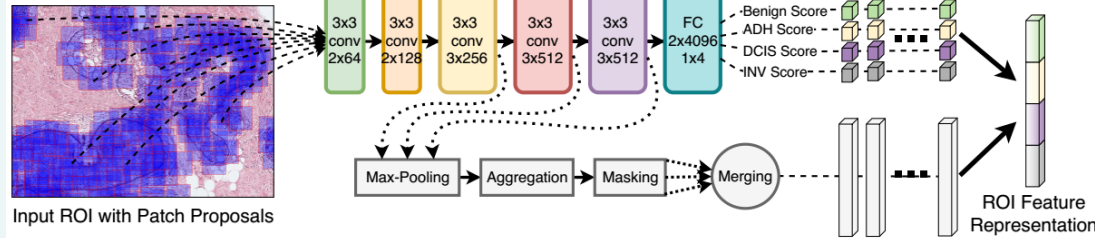
(d) Multi-label learning (MLL) scenario



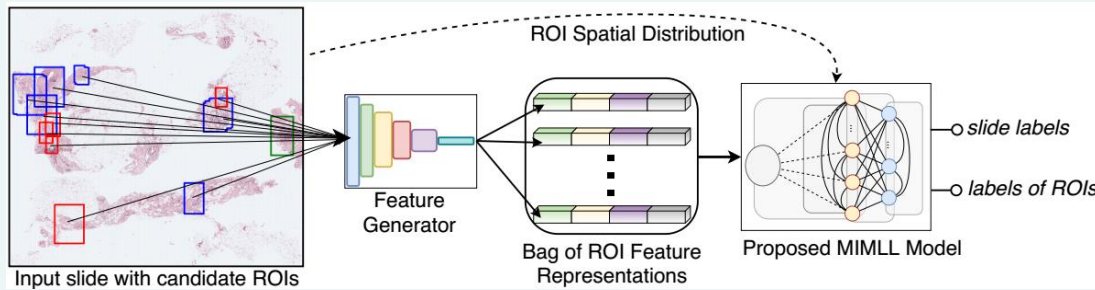
(e) Multi-instance multi-label learning (MIMLL) scenario

Different weakly supervised learning scenarios

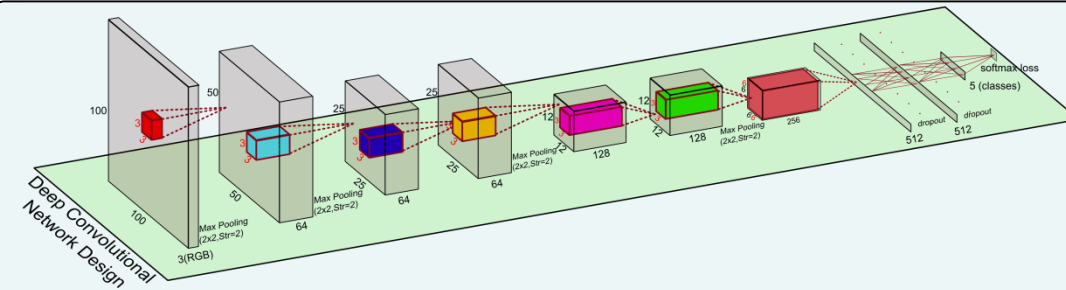
# Medical Image Analysis



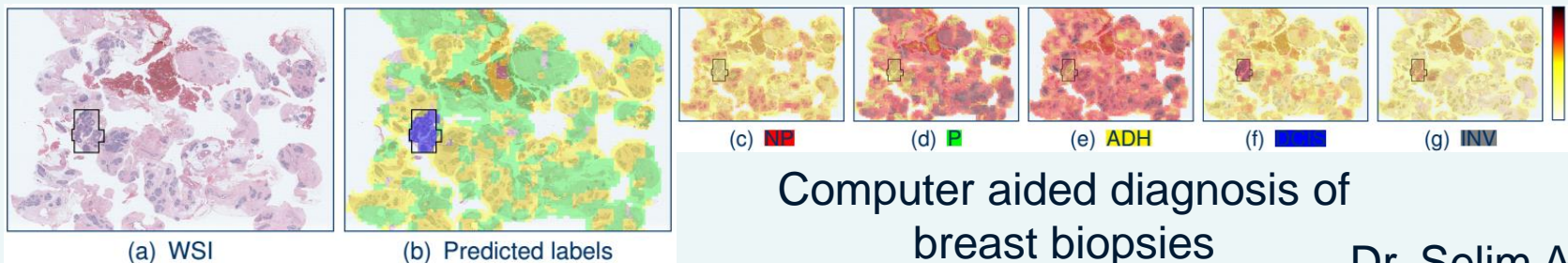
Deep feature representations



Conditional random fields for weakly supervised learning



Convolutional neural networks for region of interest classification

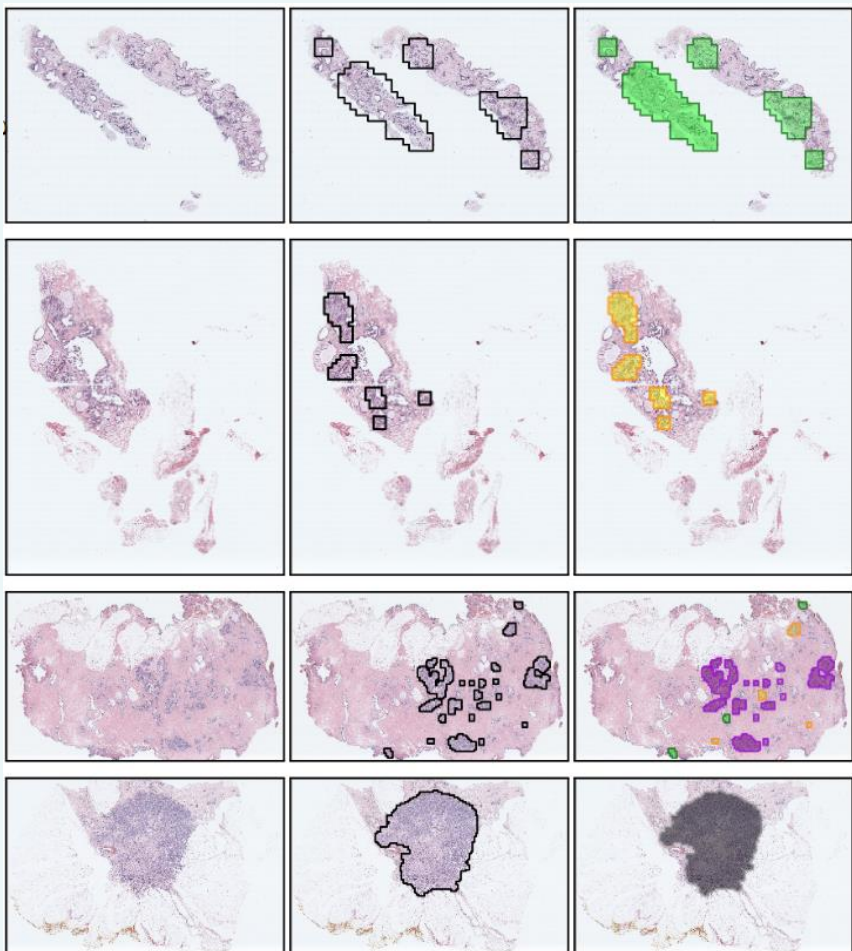


Computer aided diagnosis of breast biopsies

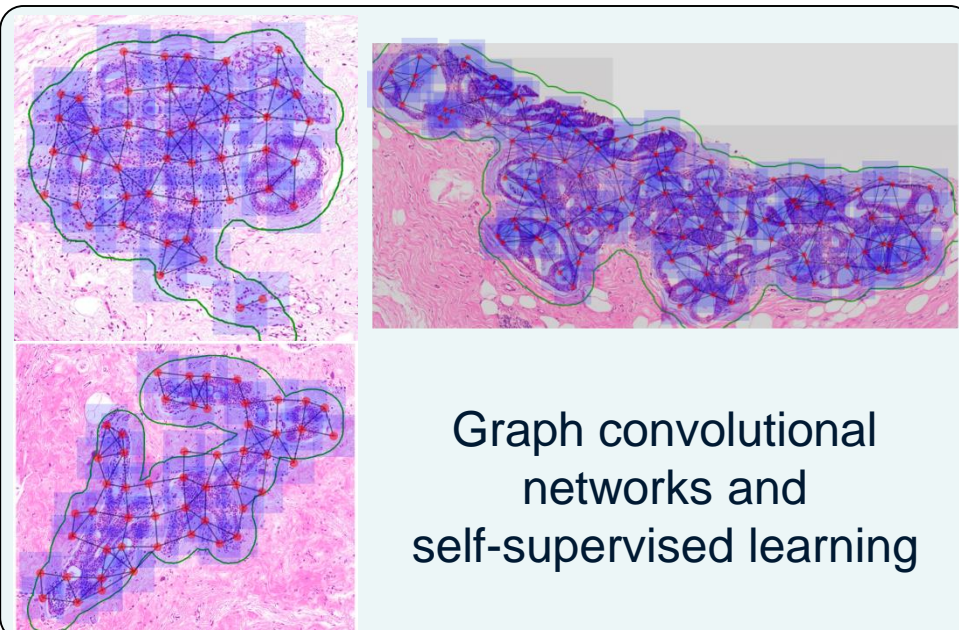
Dr. Selim Aksoy



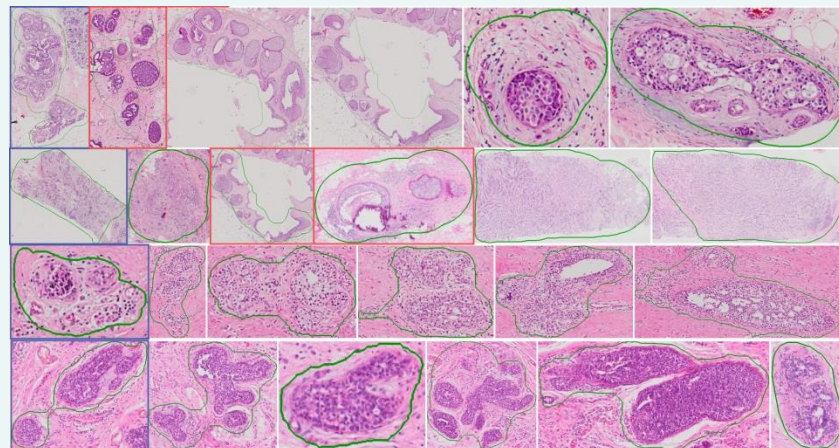
# Medical Image Analysis



Simultaneous localization  
and classification



Graph convolutional  
networks and  
self-supervised learning



Content-based search of medical archives

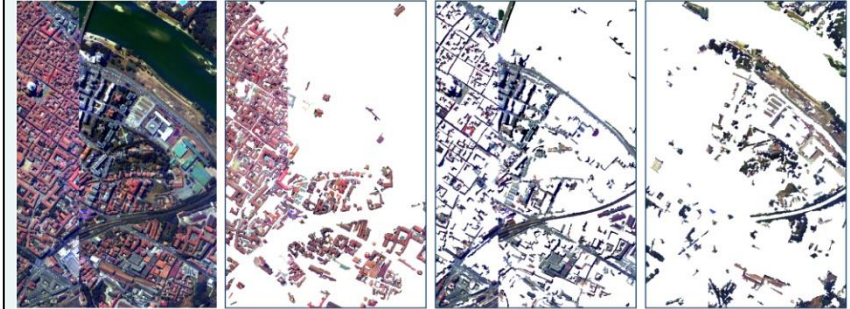


# Remote Sensing Image Analysis



(a) Landsat 5 (30 m) (1984) (b) Spot 5 (5 m) (2002) (c) WorldView-3 (0.31 m) (2014)

Increasing spatial resolution (300m  $\Rightarrow$  1-2cm)



(a) False color (b) Buildings (c) Roads (d) Vegetation

Hyperspectral image analysis



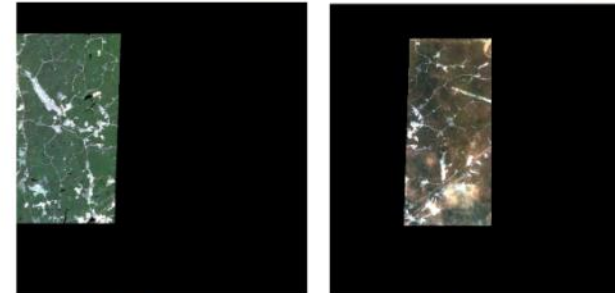
Orchard segmentation and agricultural mapping



(a) Aerial

(b) Landsat

(c) DEM



(d) Ikonos

(e) Ikonos

Multi-source fusion and missing data analysis

Dr. Selim Aksoy





# Can Alkan

calkan@cs.bilkent.edu.tr

Lab for Bioinformatics and Computational Genomics

<http://www.cs.bilkent.edu.tr/~calkan/compgen>



Combinatorial algorithms to analyze high throughput sequence data to discover, genotype, and phase genomic variants, assemble genomes and transcriptomes.

Test genome



Resequencing



Reference  
Genome

Read mapping and  
variation analysis

*De novo* sequencing



Contigs/  
Scaffolds

Assembly

# Types of genomic variants

**SNP:** Single nucleotide polymorphism (substitutions)

**Indel:** Insertions and deletions of sequence of length 1 to 50 basepairs

*reference:*

*sample:*

```
reference: C A C A G T G C G C - T
sample:    C A C C G T G - G C A T
```

SNP                  deletion      insertion

**Short tandem repeats:** microsatellites, minisatellites, alpha & beta satellites, etc.

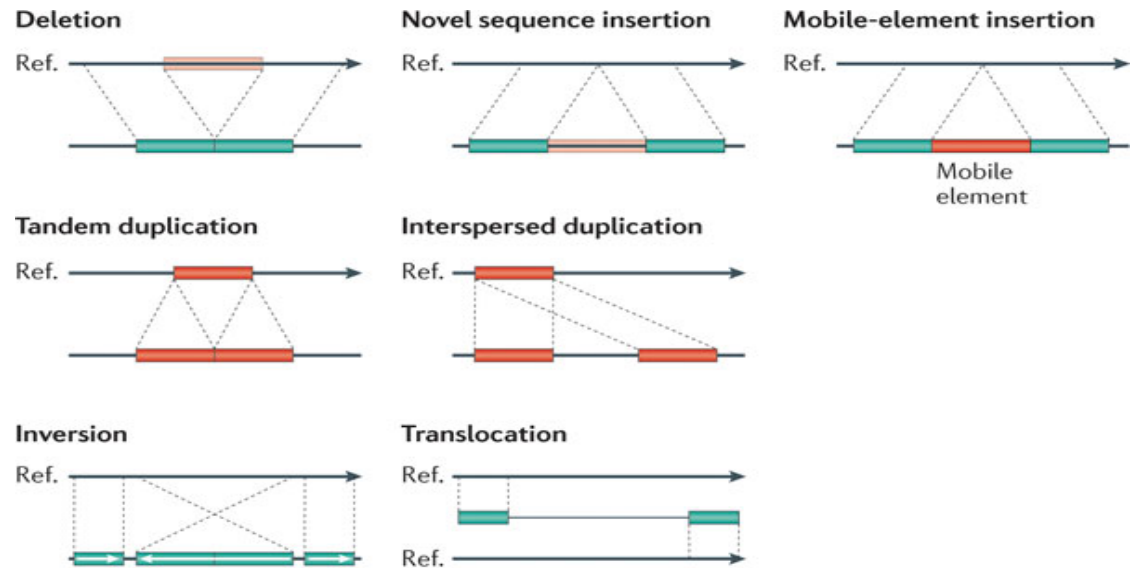
*reference:*

*sample:*

```
reference: C A G C A G C A G C A G
sample:    C A G C A G C A G C A G
```

**Structural variation:**

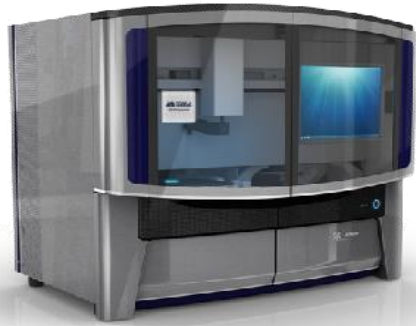
Genomic alterations > 50 bp  
Deletions, insertions, mobile  
elements, duplications,  
inversions and translocations



# Genome sequencers



Roche/454



AB SOLiD



Illumina MiSeq



Complete Genomics



Illumina HiSeq2000



Pacific Biosciences RS



Oxford Nanopore MinION



Oxford Nanopore GridION



Ion Torrent PGM



Ion Torrent Proton

... and more! All produce data with different properties.



# Selected publications

[Personalized copy number and segmental duplication maps using next-generation sequencing](#). *Nature Genetics*, Oct, 41(10):1061-1067, 2009.

\* **Highlighted** in News and Views, "Mapping duplicated sequences", DY Chiang and SA McCarroll, *Nature Biotechnology*, Nov; 27(11):1001-2, 2009.

[Combinatorial algorithms for structural variation detection in high throughput sequenced genomes](#). *Genome Research*, Jul, 19(7):1270-8, 2009.

[Detection and characterization of novel sequence insertions using paired-end next-generation sequencing](#). *Bioinformatics*, May 15; 26(10):1277-83, 2010.

[A draft sequence of the Neandertal genome](#) *Science*, 7 May, 328 (5979):710-722, 2010.

Recipient of the [2010 AAAS Newcomb Cleveland Prize](#).

[mrsFAST: a cache-oblivious algorithm for short-read mapping](#). *Nature Methods*, Aug;7(8):576-7, 2010.

[A map of human genome variation from population-scale sequencing](#). 1000 Genomes Project Consortium. *Nature*, Oct 28;467(7319):1061-73, 2010.

[Genetic history of an archaic hominin group from Denisova Cave in Siberia](#). *Nature*, Dec; 468(7327):1053-1060, 2010.

[Limitations of next-generation genome sequence assembly](#). *Nature Methods*, 8(1):61-65, 2011.

\* **Highlighted** in Commentary, "Assemblies: the good, the bad, the ugly", E. Birney, *Nature Methods*, 8(1):59-60, 2011.

[Mapping copy number variation by population-scale genome sequencing](#). *Nature*, 470(7332):59-65, 2011.

[Genome structural variation discovery and genotyping](#). *Nature Reviews Genetics*, May;12(5):363-76, 2011.

[Sensitive and fast mapping of di-base encoded reads](#). *Bioinformatics*, Jul 15;27(14):1915-21, 2011.

[Detection of structural variants and indels within exome data](#). *Nature Methods*, 9(2): 176-178, 2012.

# Projects

- ◆ Discovery and characterization of genomic variation
  - ◆ Funded by EU Marie Curie Actions Career Integration Grant
- ◆ Algorithms and hardware designs for ultra-fast mapping of HTS reads to reference genome assemblies
  - ◆ Funded by US National Institutes of Health
- ◆ De novo and hybrid (multi-platform) sequence assembly.
- ◆ Genomic repeat discovery, classification and annotation.
- ◆ Distributed algorithms for genome assembly.

Positions available. Contact if you have B.Sc. or M.Sc. degree in computer science, computer engineering, electrical engineering, or mathematics, and if you are interested in combinatorial optimization, approximation algorithms, and graph theory. Strong programming skills in C/C++ are highly desired.

Successful applicants will also have a chance to contribute to many international consortiums such as the 1000 Genomes Project and the Genome 10K, and will involve in other international collaborations with researchers in Vancouver, Seattle, Barcelona, Bari, Pittsburgh, and more.

Basic understanding of biology/genetics/genomics is a *plus*, but **not required**.

# Shervin Rahimzadeh Arashloo

s.rahimzadeh@cs.bilkent.edu.tr

www.cs.bilkent.edu.tr/~s.rahimzadeh

Office: EA 429

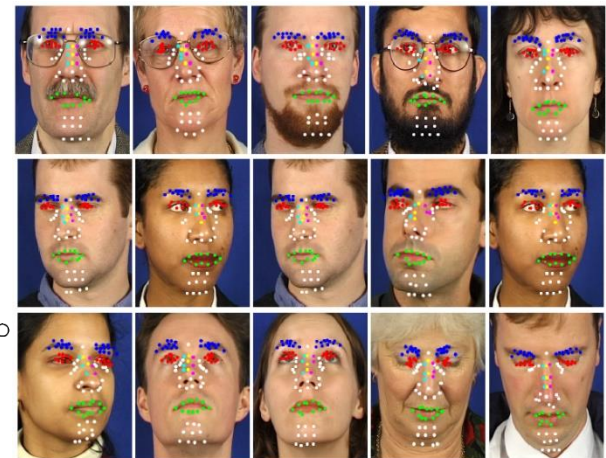
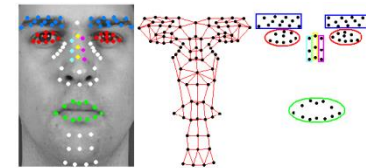
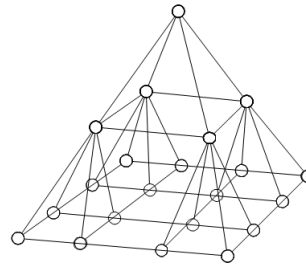
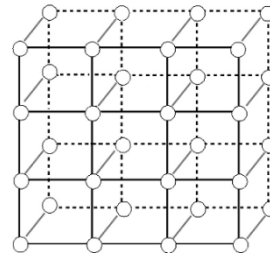
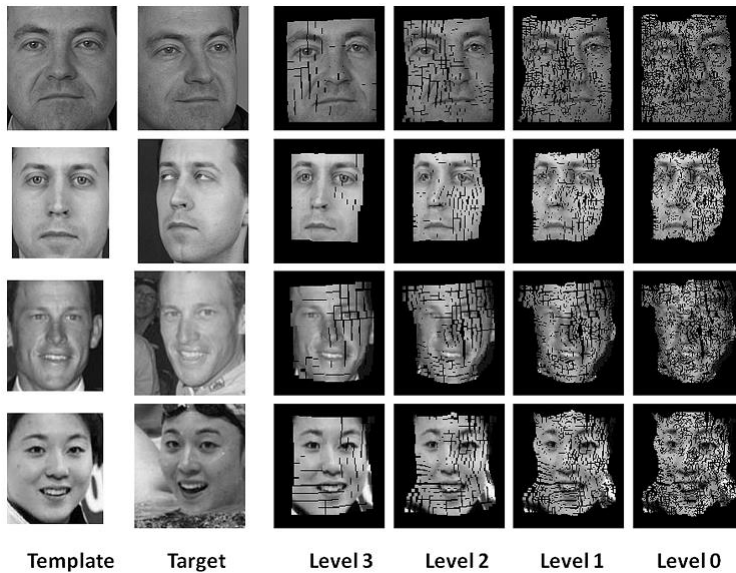
## Research Interests

- Computer Vision
- Pattern Recognition
- Machine Learning

## Current Research Topics

- Face Recognition
- Face Presentation Attack Detection
- Anomaly Detection

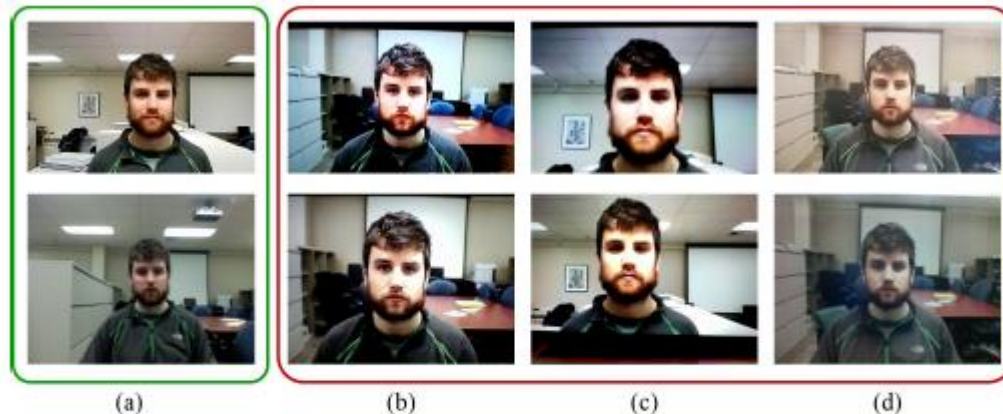
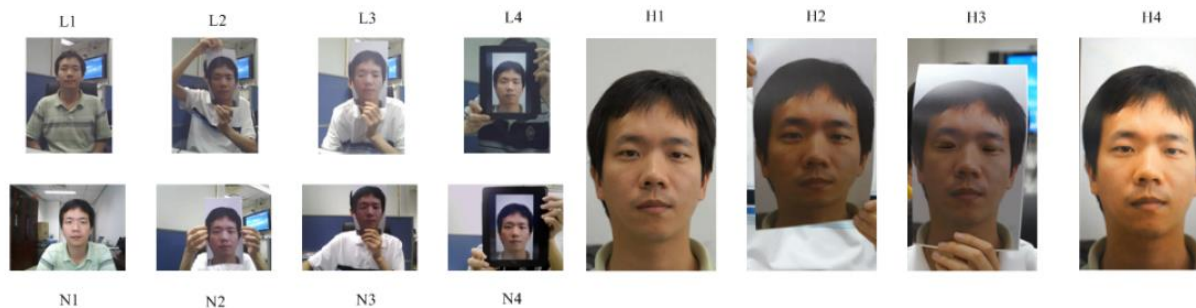
# Unconstrained Face Recognition





# Face Presentation Attack Detection

Securing face recognition systems against security threats made by fake biometric traits



Sample data from the MSU dataset.(a) Genuine faces;  
(b)-(d) Spoof faces.

# Anomaly Detection

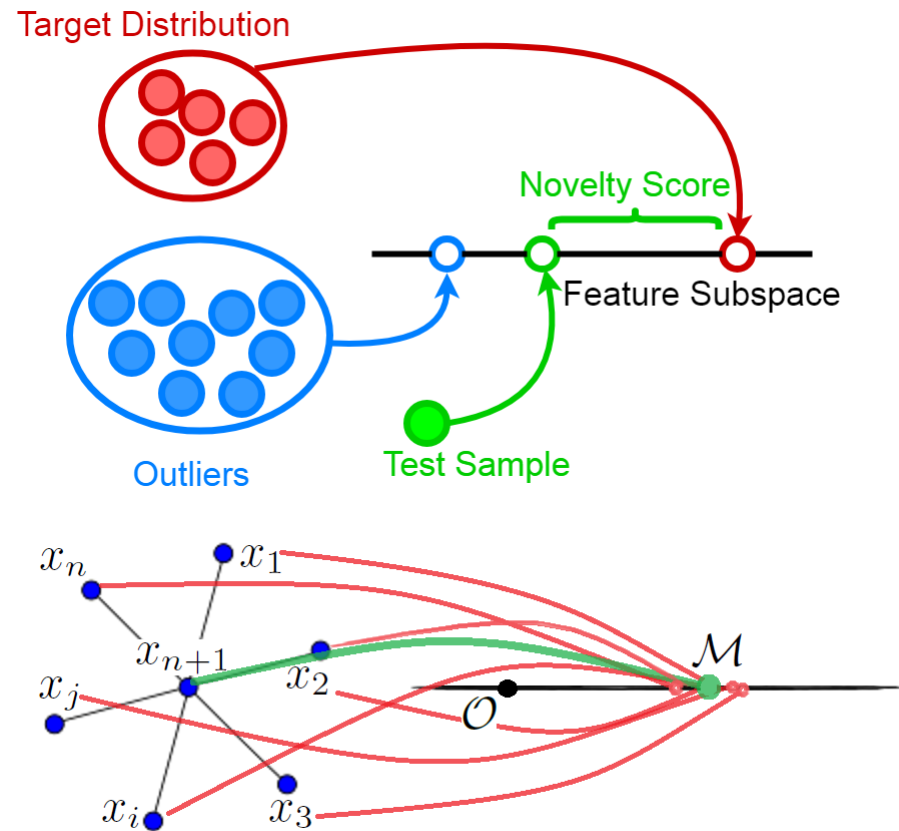
Developing novel methodologies along with applications to:

Surveillance

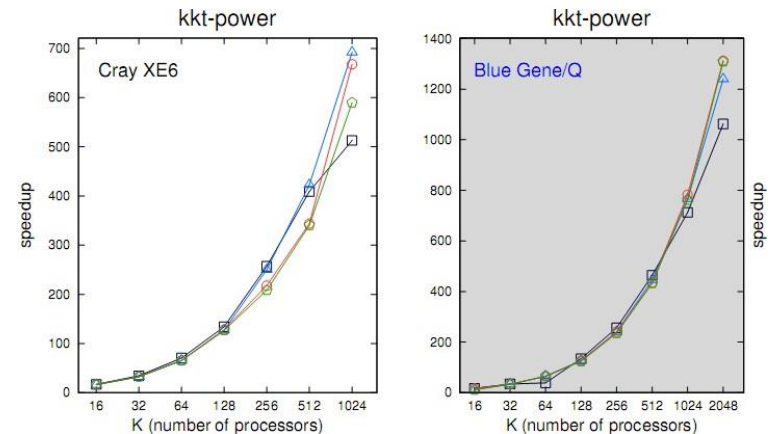
Novelty detection

Healthcare

etc.



- Recent research interest and expertise
  - Combinatorial scientific computing**
  - Iterative solvers:** novel partitioning models, algorithms and software utilities for development of parallel iterative methods for linear-system solutions
  - Optimizing latency-centric communication metrics for petascaling **sparse solvers**
  - Partitioning **irregular domains** for large-scale parallel processing
  - Locality aware scheduling of irregular applications on **Many Core** architectures
  - Partitioning models for scaling 1D-, 2D- and 3D-parallel **sparse matrix-matrix multiply**
  - Partitioning large scale **social networks** and **graph databases**
  - Parallel graph analytics** kernels for big data applications
- **HPC for Machine Learning and ML for HPC**
  - Partitioning methods for scalable sparse **Tensor decomposition**
  - Scaling parallel **stochastic gradient descent** algorithms for **ML**
  - Fast and efficient model parallelism for **Deep CNNs**
  - Task leader in FP7 / Horizon2020 **PRACE** projects: 1IP, 2IP, 3IP, 4IP, 5IP



Speedup curves of Conjugate Gradient solver for different methods on a Cray and BlueGene/Q machine  
(kkt-power matrix: 2 million rows, 12 million nonzeros)

## Contact Address:

Prof. Cevdet Aykanat

[aykanat@cs.bilkent.edu.tr](mailto:aykanat@cs.bilkent.edu.tr)

<http://www.cs.bilkent.u.tr/~aykanat/>

# Recent Publications (2018-2021)

- True Load Balancing for Matricized Tensor Times Khatri-Rao Product, *Nabil Abubaker, Seher Acer, Cevdet Aykanat*, **IEEE Transactions on Parallel and Distributed Systems** vol. 32, no. 8, pp. 1974-1986, 2021.
- Fast Shared-Memory Streaming Multilevel Graph Partitioning *Oguz Selvitopi, Nazanin Jafari, and Cevder Aykanat*, **Journal of Parallel and Distributed Computing**, vol. 31, no. 8, pp. 140-151, 2021.
- Partitioning Models for General Medium-Grain Parallel Sparse Tensor Decomposition *M. Ozan Karsavuran, Seher Acer and Cevder Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 32, no. 1, pp. 147-159, 2021.
- Cartesian Partitioning Models for 2D and 3D Parallel SpGEMM Algorithms, *Gunduz V. Demirci and Cevder Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 31, no 12, pp. 2763-2775, 2020.
- Reordering Sparse Matrices into Block-Diagonal Column-Overlapped Form, *Seher Acer and Cevder Aykanat*, **Journal of Parallel and Distributed Computing**, vol. 140, pp. 99-109, 2020.
- Reduce Operations: Send Volume Balancing While Minimizing Latency, *M. Ozan Karsavuran, Seher Acer, and Cevder Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 31, no. 6, pp. 1461-1473, 2020.
- The Effect of Various Sparsity Sturcuters on Parallelism and Algorithms to Reveal Those Strctures, *Oguz Selvitopi, Seher Acer, Murat Manguoglu and Cevdet Aykanat*, **Parallel Algorithms in Computational Science and Engineering**, 35-62, 2020.
- Regularizing irregularly sparse point-to-point communications, *Oguz Selvitopi and Cevdet Aykanat* **Proceedings of the International Conference for High Performance Computing**, Networking, Storage and Analysis. ACM, 2019.
- A Hypergraph Partitioning Model for Profile Minimization, *Seher Acer, Enver Kayaaslan, Cevdet Aykanat*, **SIAM Journal on Scientific Computing**, vol. 41, no. 1, pp. A83-A108, 2019.
- Locality-aware and load-balanced static task scheduling for MapReduce, *Oguz Selvitopi, Gunduz V. Demirci, Ata Turk, Cevdet Aykanat*, **Future Generation Computer Systems**, vol. 90, pp. 49-61, 2019.
- Scaling Sparse Matrix-Matrix Multiplication in the Accumulo Database, *Gunduz V. Demirci, Cevdet Aykanat*, **Distributed and Parallel Databases**, pp 1-32, 2019.
- Spatiotemporal Graph and Hypergraph Partitioning Models for Sparse Matrix-Vector Multiplication on Many-Core Architectures, *Nabil Abubaker, Kadir Akbudak, Cevder Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 30, no. 2, pp. 445-458, 2019.
- A novel partitioning method for accelerating the block cimmino algorithm, *Sukru Torun, Murat Manguoglu, Cevdet Aykanat*, **SIAM Journal on Scientific Computing**, 40(6) C827-C850, 2018.
- Cascade-aware partitioning of large graph databases, *Gunduz V. Demirci, Hakan Ferhatosmanoglu, Cevdet Aykanat*, **The VLDB Journal**, pp. 1-22, 2018.
- Optimizing nonzero-based sparse matrix partitioning models via reducing latency, *Seher Acer, Oguz Selvitopi, Cevdet Aykanat*, **Journal of Parallel and Distributed Computing**, vol122, pp145-158, 2018.
- Improving medium-grain partitioning for scalable sparse tensor decomposition, *Seher Acer, Tugba Torun, Cevdet Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 29, no. 12, pp. 2814-2825, 2018.
- 1.5 D parallel sparse matrix-vector multiply, *Enver Kayaaslan, Cevdet Aykanat, Bora Ucar*, **SIAM Journal on Scientific Computing**, vol. 40, no. 1, pp. C25-C46, 2018.
- Partitioning models for scaling parallel sparse matrix-matrix multiplication, *Kadir Akbudak, Oguz Selvitopi, Cevdet Aykanat*, **ACM Transactions on Parallel Computing (TOPC)**, vol. 4, no. 3, pp. 13, 2018.

**Contact Address:**

Prof. Cevdet Aykanat

[aykanat@cs.bilkent.edu.tr](mailto:aykanat@cs.bilkent.edu.tr)

<http://www.cs.bilkent.u.tr/~aykanat/>

# Recent Funded Projects

- **TUBITAK/COST Projects**

- 119E035: Parallel Stochastic Gradient Descent Algorithms for Large-Scale Recommendation Systems, 15/09/2019 - 15/02/2022
- 116E043: High Performance Tensor Decomposition Methods for Distributed and Shared Memory Parallel Systems, 01/05/2017 – 1/11/2019
- 115E212/COST-CA15109: Improving Sparse Matrix Based Graph Analytics Kernels for Big Data Applications, 01/09/2015 - 01/03/2018
- 114E545/COST-IC1406: Petascaling Sparse Iterative Solvers via Optimizing Multiple Communication Metrics, 01/04/2015 - 01/10/2017
- 112E120: Partitioning, Replication and Query Processing in Social Networks, 01/09/2012 - 01/09/2014

- **FP7/HORIZON-2020 Projects**

- PRACE 6IP 01/05/2019 – 01/05/2021
  - Task 7.4: Evaluation of Benchmark Performance
- PRACE 5IP 01/01/2017 – 01/05/2019
  - Task 7.2: Preparing for PRACE Exascale Systems
- PRACE 4IP 01/02/2015 - 01/05/2017
  - Task 7.2: Preparing for Future PRACE Exascale Systems
  - Task 4.3: On-line Training. Subtask: Evaluation of platforms for the CodeVault
- PRACE 3IP 01/08/2012 - 01/08/2014
  - D7.2.1 HPC Tools and Techniques
- PRACE 2IP 01/07/2011 - 01/07/2014
  - D12.5 Summary of Novel Programming Techniques Results (Taskleader)
- PRACE 1IP-Extension 01/07/2013 - 01/07/2014
  - D7.1.3 Application Enabling for Capability Science in the MICArchitecture
- PRACE 1IP 01/07/2010 - 01/07/2013
  - D7.5 HPC Programming Techniques (Task leader)

## Current Positions of Some Former PhD. Students

- Dr. Ozan Karsavuran, 2020. **Bilkent University**, Postdoctoral Researcher
- Dr. G. Vehbi Demirci, 2019. **University of Warwick**, Postdoctoral Researcher
- Dr. Seher Acer, 2017. **Oak Ridge National Lab.**, Research Scientist
- Dr. Oguz Selvitopi, 2017. **Lawrence Berkeley Nat. Lab.**, Research Scientist
- Dr. Şükrü Torun, 2017. **Yıldırım Beyazıt University**, Assistant Professor
- Dr. Kadir Akbudak, 2015. **University of Tennessee**, Research Scientist
- Dr. Enver Kayaaslan, 2013. **Google Switzerland**, Researcher
- Dr. Ertuğrul Tabak, 2013. **Aurea Software**, Software engineering manager
- Dr. Eray Özkural, 2013. **Celestial Intellect Cybernetics**, Software engineer
- Dr. Tayfun Küçükyılmaz, 2012. **TED University**, Assistant Professor
- Dr. Ata Türk, 2010. **Boston University**, Research Scientist,
- Dr. Engin Demir, 2009. **Hacettepe University**, Assistant Professor
- Dr. Barla Cambazoğlu, 2006. **RMIT University**, Senior Research Fellow
- Dr. Bora Uçar, 2005. **LIP ENS-LYON**, CNRS researcher.
- Dr. Ümit Çatalyürek, 1999. **Georgia Institute of Technology**, Professor
- Dr. Tahsin Kurc, 1997. **Stony Brook University**, Associate Professor

# Bilkent Information Retrieval Group



## **Faculty**

Fazlı Can  
Seyit Koçberber

## **Graduate Students**

Soheil Abadifard  
Sepehr Bakhshi  
Pouya Ghahramanian  
Sanaz Gheibuni  
Oğuzhan Özçelik  
Onur Yıldırım

## **UG Student(s)**

Enes Bektaş

## **Some Prev. Members**

Alican Büyükçakır  
Sevil Çalışkan  
Sanem Elbaşı  
Ömer Gözüaçık  
Berkay Gülcan  
Çağdaş Öcalan

## **Other Contributors**

Hamed R. Bonab, Umass  
Dilek Küçük, TÜBİTAK  
Çağrı Toraman, ASELSAN

# Research Interests



## Information Retrieval (IR)

- Information Filtering
- News Aggregation and Categorization
- Turkish Text Mining
- Literature Analysis

## Data Stream Mining

- Ensemble Models for Stream Classification
- Multi-label Classification
- Concept Drift Detection
- Multi-stream Processing
- Stance Detection



# You are the right person for our group



- If you are good at four core practices of computer science

- programming,
- systems thinking,
- modeling, and
- innovation.

- If you

- can dream,
- can do, and
- can write.



# A. Ercument Cicek

cicek@cs.bilkent.edu.tr

cs.bilkent.edu.tr/~cicek



My research focuses on building algorithms for analyzing biological data using various biochemical networks. Even though it took 13 years and ~\$1b to sequence the first genome, right now, it takes a day and ~\$1k. This has resulted in accumulation of vast amounts of information. Consequently, biosciences have faced the problem of “big data”. Today, the bottleneck in the bio-research is the lack of computational power and algorithms that can efficiently analyze the data and make discoveries. Central dogma in molecular biology dictates the information flow from DNA -> RNA --> Protein --> Metabolite. Each layer introduces 20k, 100k, 1m, and 3k variables respectively. The search space for even a basic pattern discovery is clearly intractable. I design machine learning algorithms that use biological networks to prune the search space and discover biomarkers in particular for genetic Diseases.

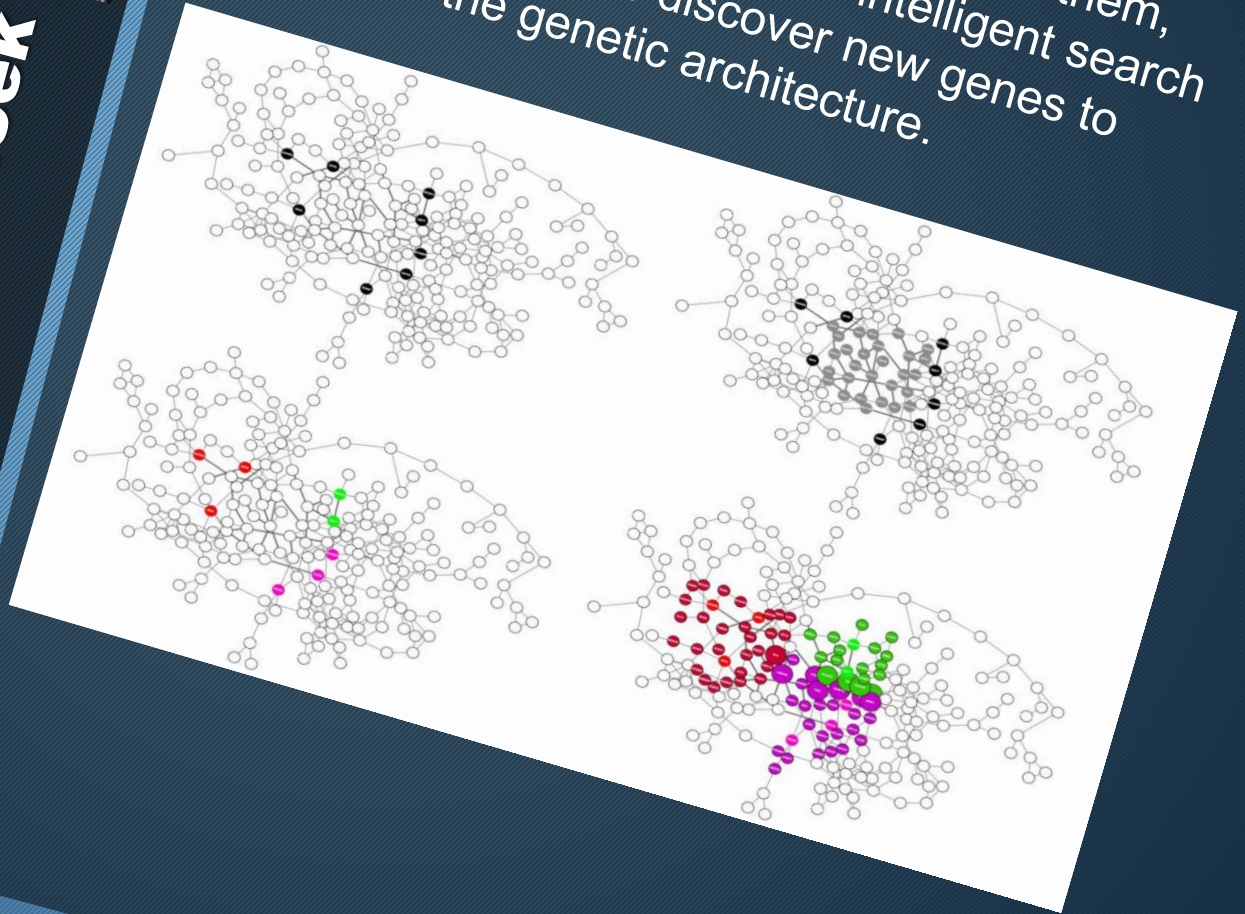


**A. Ercument Cicek**  
**cicek@cs.bilkent.edu.tr**  
**cs.bilkent.edu.tr/~cicek**



## Gene Discovery for Autism Spectrum Disorder

- Broken interplay between 1000 genes lead to autism.
  - So far we have only discovered ~50 of them,
- Biological networks along with intelligent search algorithms needed to discover new genes to understand the genetic architecture.



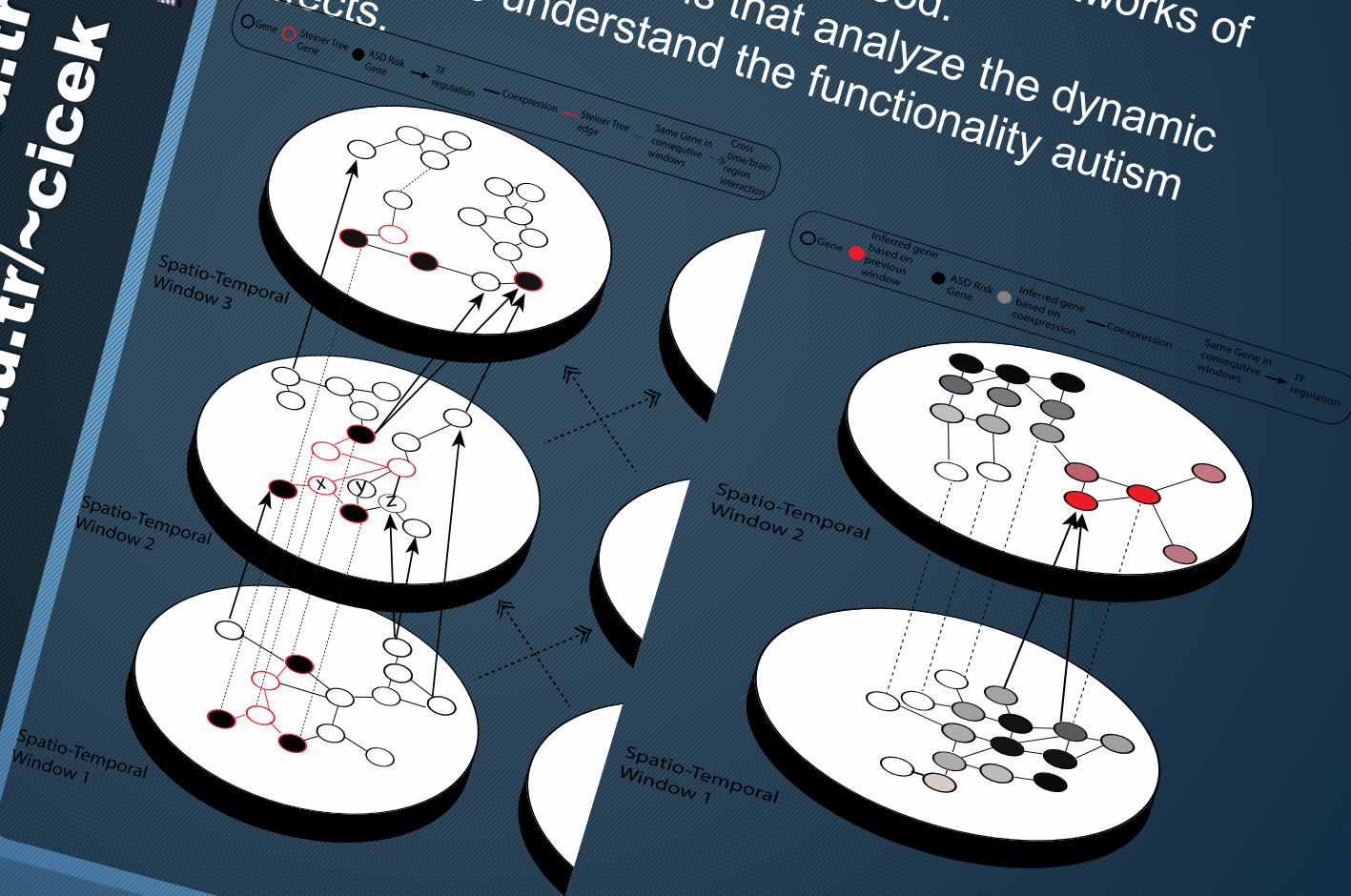


**A. Ercument Cicek**  
**cicek@cs.bilkent.edu.tr**  
**cs.bilkent.edu.tr/~cicek**



## Using Dynamic Network Algorithms to Model Neurodevelopment.

- Autism is a neurodevelopmental disorder and affects evolving the gene interaction networks of the fetal period to early childhood.
- We design algorithms that analyze the dynamic networks to understand the functionality autism affects.









**A. Ercument Cicek**  
**cicek@cs.bilkent.edu.tr**  
**cs.bilkent.edu.tr/~cicek**



**Selected Publications:**

- *De Novo Chip-Seq Analysis. **Genome Biology** 2015, 16:205.*
- *Insights into autism spectrum disorder genomic architecture and biology from 71 risk loci **NEURON** 2015, 87(6):1215–33.*
- *Exome analyses reveal new autism genes in synaptic, transcriptional, and chromatin networks. **NATURE** 2014, 515(7526):209-15*
- *MIRA: Mutual Information-based Reporter Algorithm for Metabolic Networks **Bioinformatics** 2014, 30(12):i175-i184.*
- *DAWN: A framework to identify autism genes and subnetworks using gene expression and genetics **Molecular Autism** 2014 5:22.*
- *ADEMA: An Algorithm to Determine Expected Metabolite Level Changes Using Mutual Information **PLoS Computational Biology** 2013, 9(1) : e1002859.*





# Hamdi Dibeklioglu

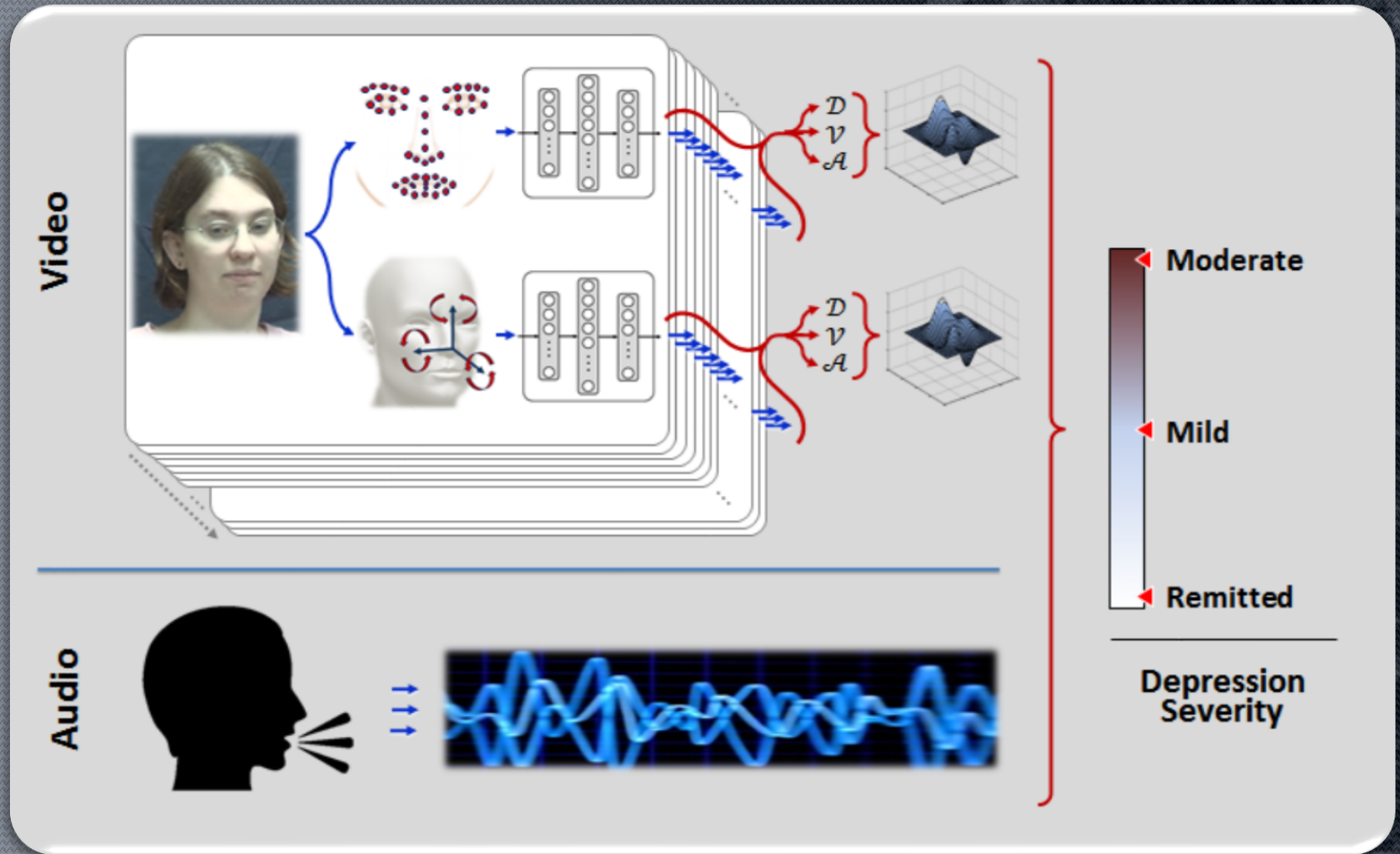
[dibeklioglu@cs.bilkent.edu.tr](mailto:dibeklioglu@cs.bilkent.edu.tr)

<http://www.cs.bilkent.edu.tr/~dibeklioglu/>

I work in the fields of Affective Computing, Computer Vision, and Pattern Recognition.

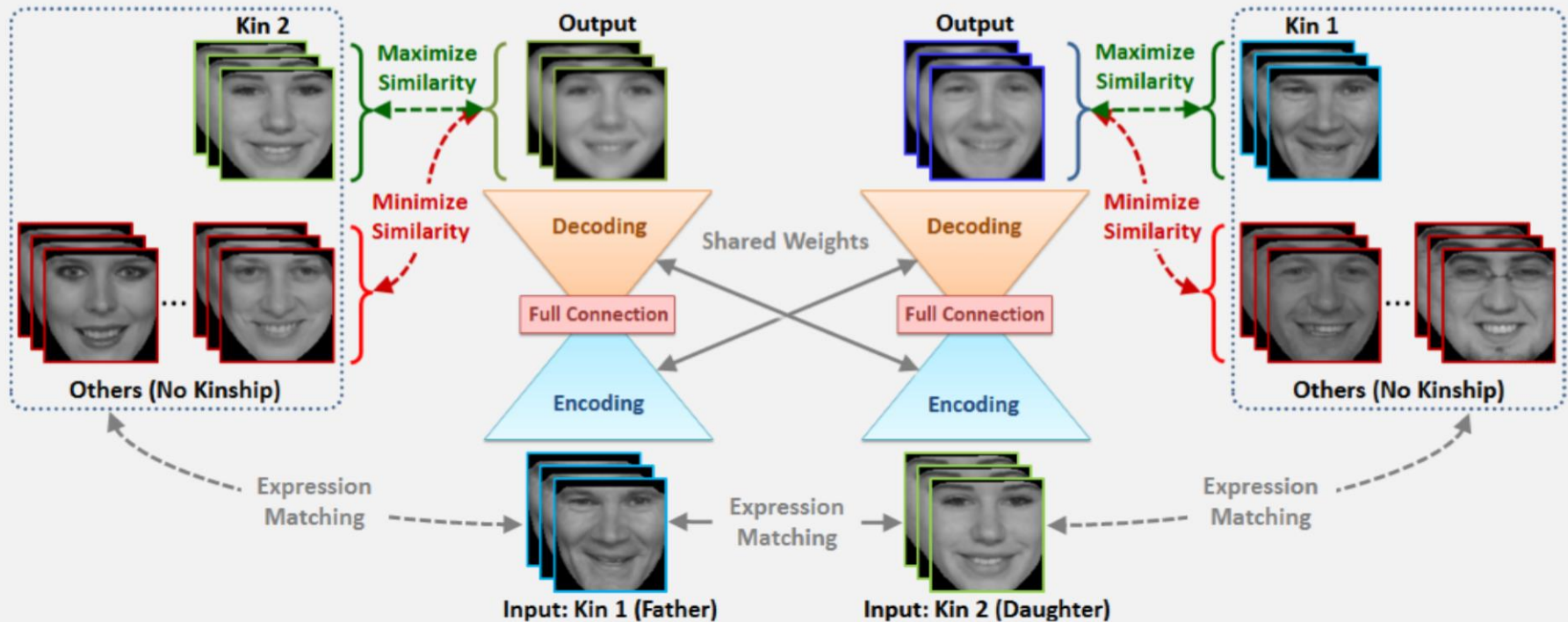
My current research mainly focuses on multimodal analysis of non-verbal human behavior (e.g. face analysis, gesture recognition, etc.) and deep learning of temporal representations.

# Assessment of Depression Severity

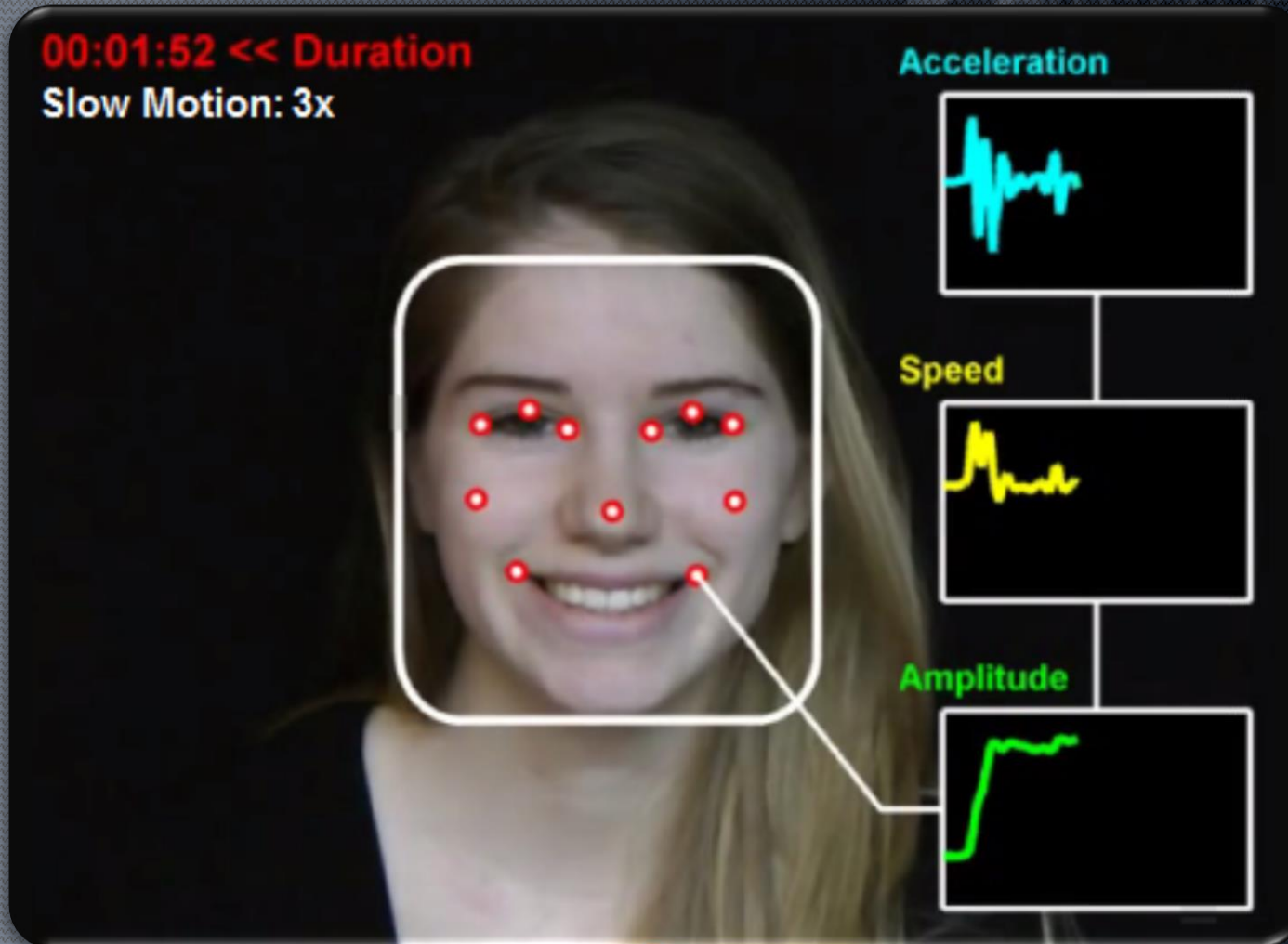




# Kinship Verification



# Age Estimation through Facial Dynamics





# *Facial Expression Recognition*





## *Selected Publications*

- *Dynamic multimodal measurement of depression severity using deep autoencoding. IEEE Journal of Biomedical and Health Informatics*, 2018, 22(2):525-536.
- *Multivariate time series classification using the hidden-unit logistic model. IEEE Transactions on Neural Networks and Learning Systems*, 2018, 29(4):920-931.
- *Visual transformation aided contrastive learning for video-based kinship verification. IEEE International Conference on Computer Vision*, 2017, 2459-2468.
- *Combining facial dynamics with appearance for age estimation. IEEE Transactions on Image Processing*, 2015, 24(6):1928-1943.
- *Recognition of genuine smiles. IEEE Transactions on Multimedia*, 2015, 17(3):279-294.



# i-Vis @ Bilkent

## Information Visualization Research Lab at Bilkent University



Info. Visualization  
Research Lab.

Big data visualization & analytics, Pathway visualization & informatics,  
Graph drawing & layout, Graph database querying algorithms

Ugur Dogrusoz

*Click [here](#) for live/animated/full presentation*



Aysegul Dundar  
<http://www.cs.bilkent.edu.tr/~adundar/>  
adundar@cs.bilkent.edu.tr



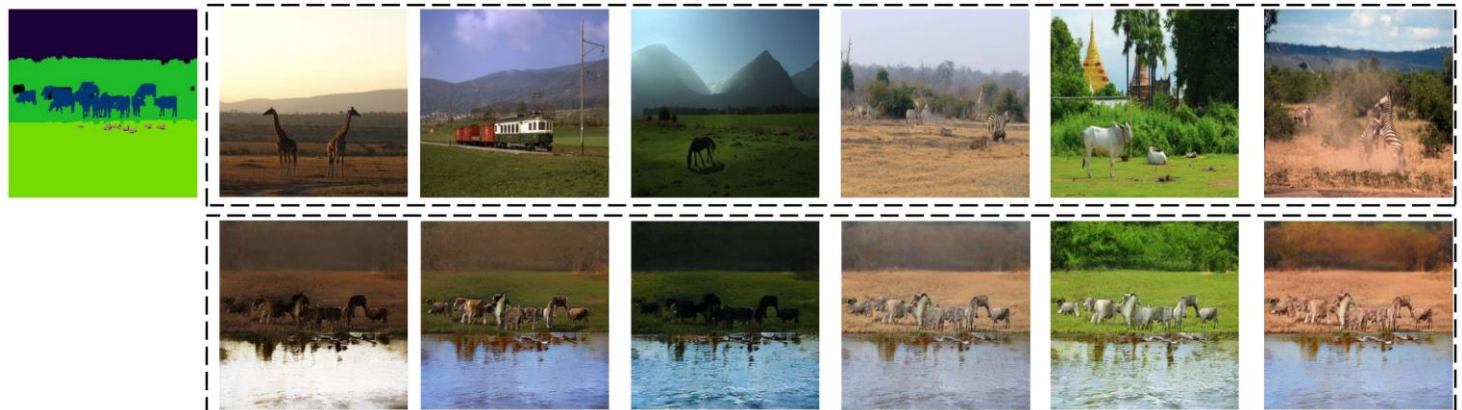
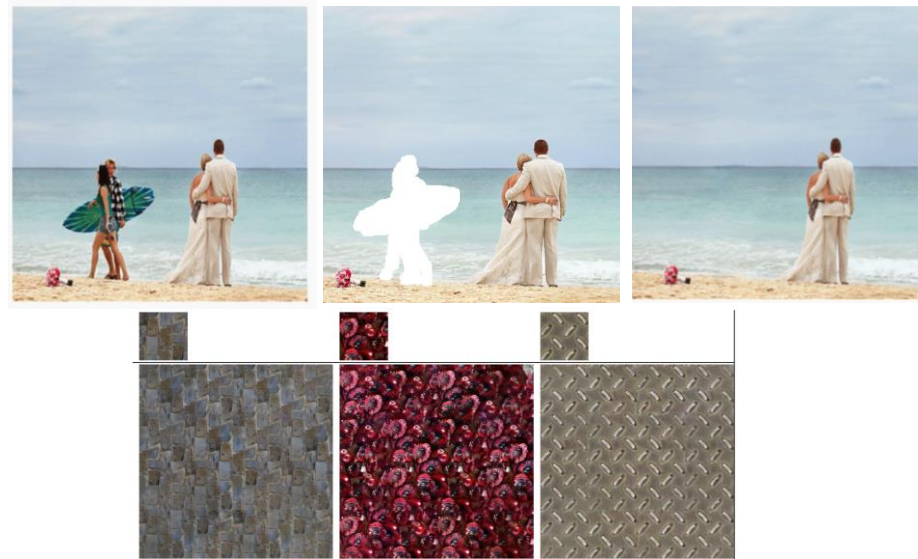
## Image Synthesis with Deep Neural Networks

Image inpainting

Texture synthesis

Image synthesis

Image to image translation

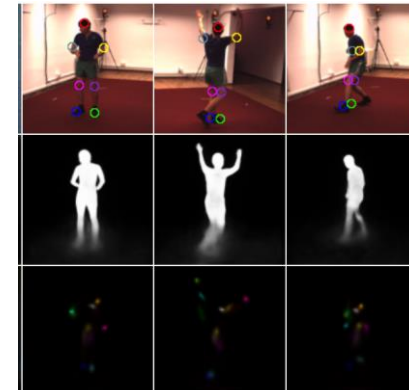
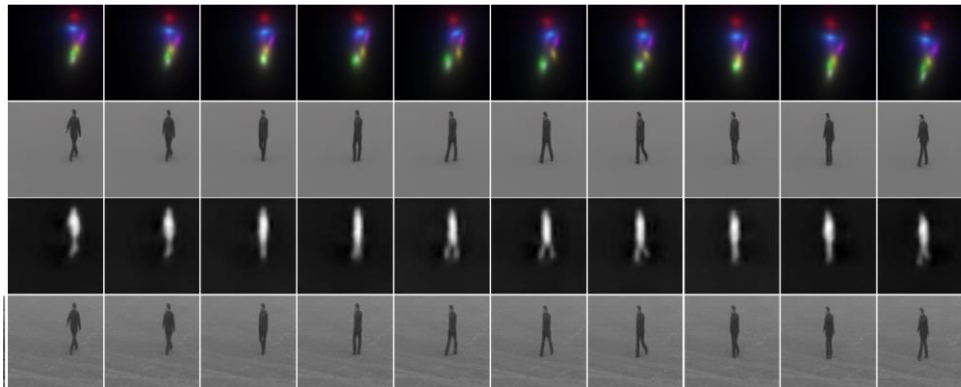
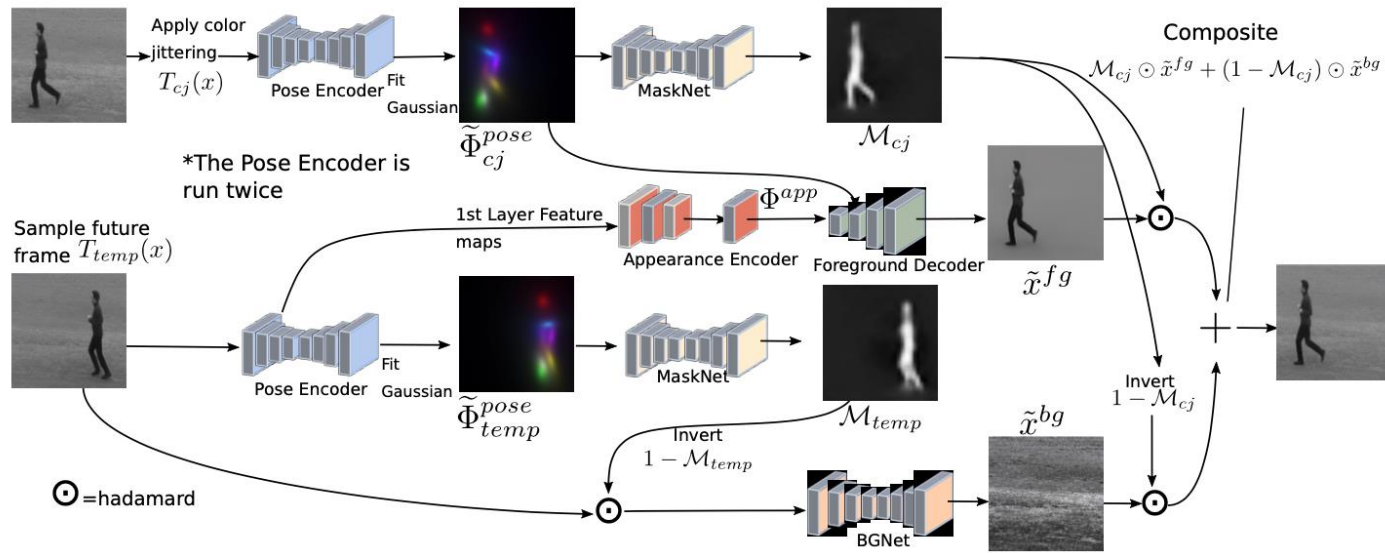


Aysegul Dundar

<http://www.cs.bilkent.edu.tr/~adundar/>  
adundar@cs.bilkent.edu.tr



## Unsupervised feature learning with Deep Neural Networks

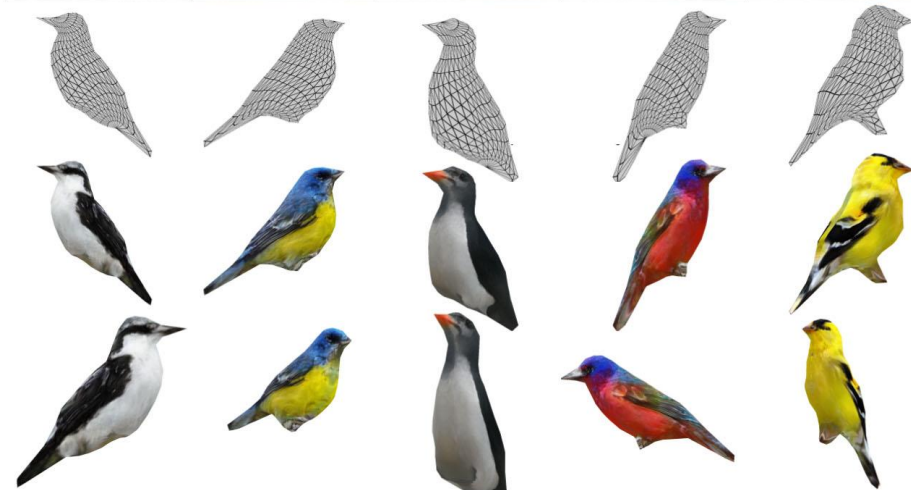
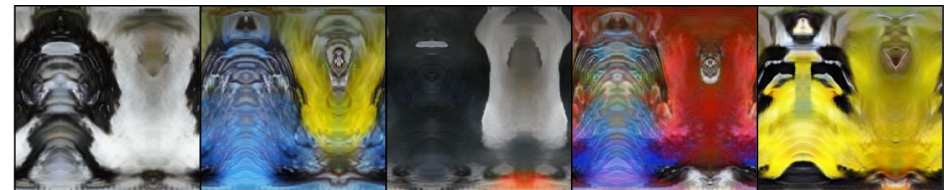
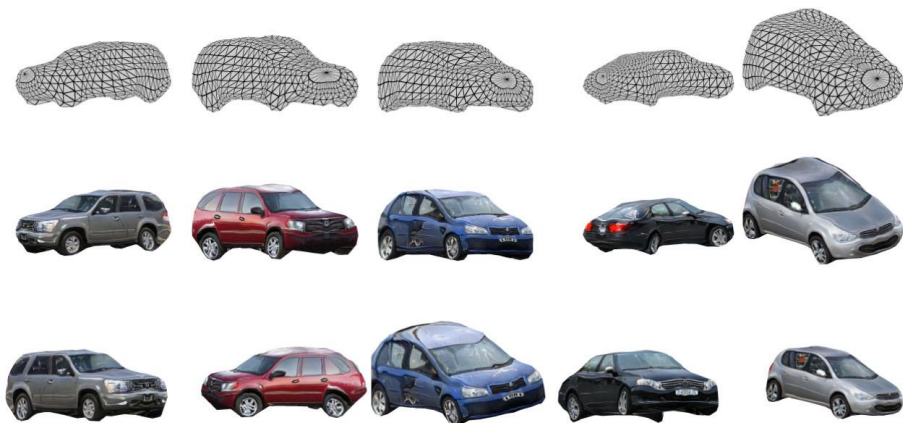


Aysegul Dundar

<http://www.cs.bilkent.edu.tr/~adundar/>  
adundar@cs.bilkent.edu.tr



## Unsupervised 3D image synthesis





# Computer Graphics

Uğur GÜDÜKBAY

**gudukbay@cs.bilkent.edu.tr**

**<http://www.cs.bilkent.edu.tr/~gudukbay>**

**Modeling and Visualization Research Group**

**<http://www.cs.bilkent.edu.tr/~modvis/>**

# Computer Graphics

**Computer Graphics Research Group** at the Department of Computer Engineering at Bilkent University conducts research on different aspects of computer graphics.

## Human Modeling and Animation

- Motion control, Realistic rendering, Facial animation, Hair simulation, Motion capture
- Augmented Reality
- Crowd simulation
- Agent Personality and Emotion Modeling
- Learning Personality and Emotions

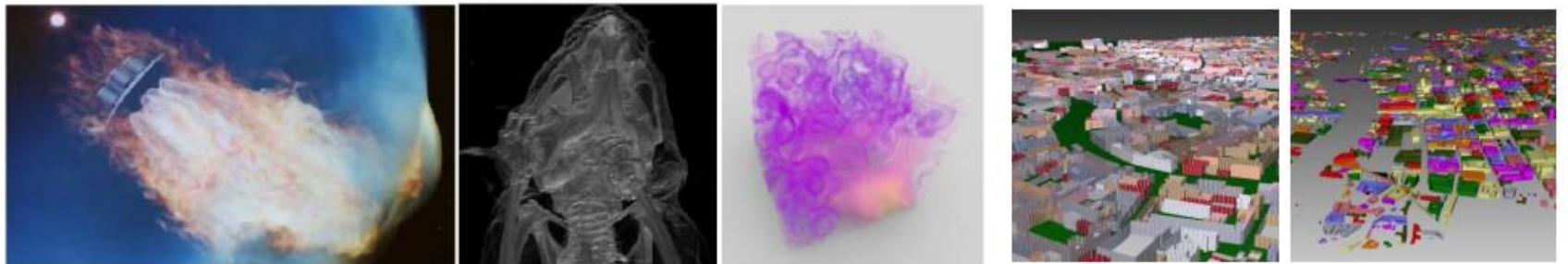


## Three-Dimensional (3D) Modeling

- Tetrahedralization of Large Models
- Terrain and Urban Scenes

## Rendering

- Tetrahedralization-based Acceleration Structures for Raytracing
- Direct Volume Visualization Using Tetrahedralization-based structures



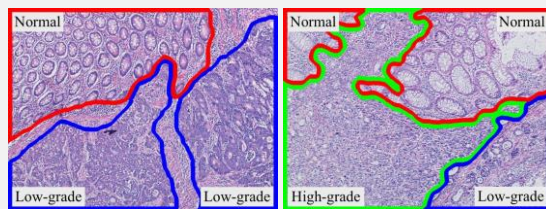
# Çiğdem Gündüz Demir

<http://www.cs.bilkent.edu.tr/~gunduz>

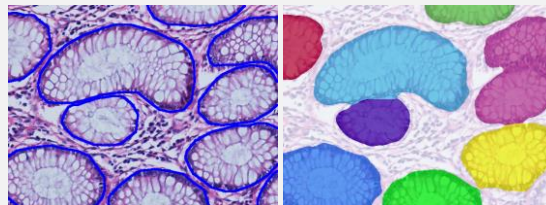
[gunduz@cs.bilkent.edu.tr](mailto:gunduz@cs.bilkent.edu.tr)



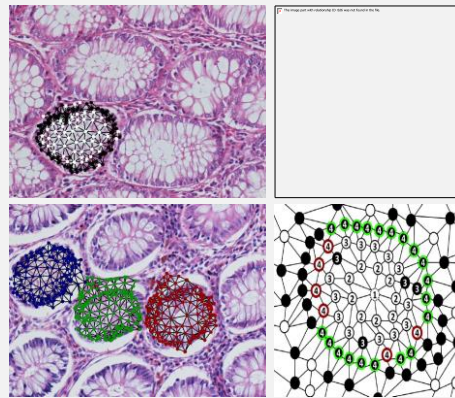
## Digital pathology: classification and segmentation in biopsy images



End-to-end segmentation in biopsy images

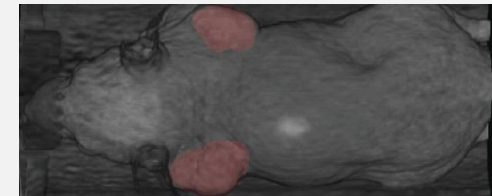


Gland/cell segmentation in colon tissues

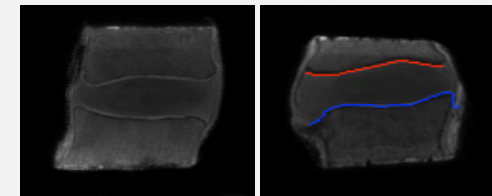


High-level representation of histopathological images and colon cancer classification

## CT and MR image analysis for in vivo images

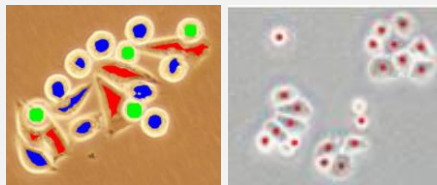


Subcutaneous tumor segmentation

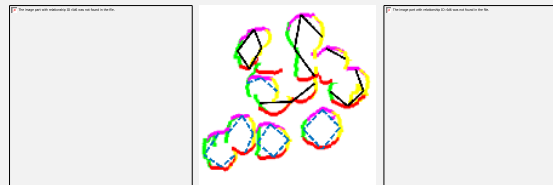


Cartilage endplate segmentation

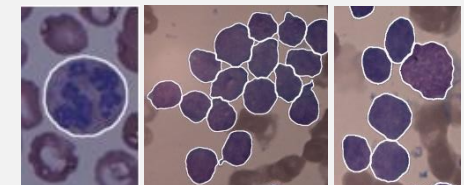
## High content screening: cell segmentation in microscopic images



Cell segmentation in phase contrast microscopy



Cell segmentation in fluorescence microscopy



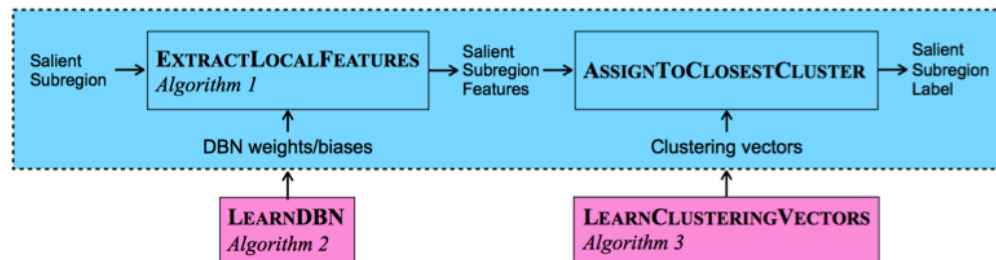
Cell segmentation in peripheral blood and bone marrow images



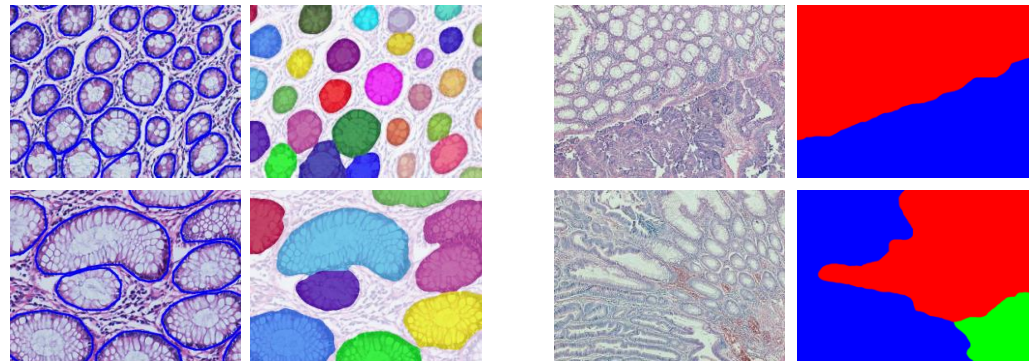
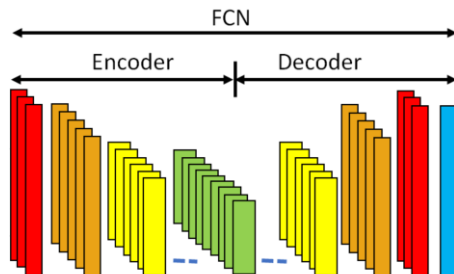
# Deep Learning for Medical Image Analysis

## Digital Pathology

Unsupervised feature extraction via deep neural networks for histopathological image representation and classification



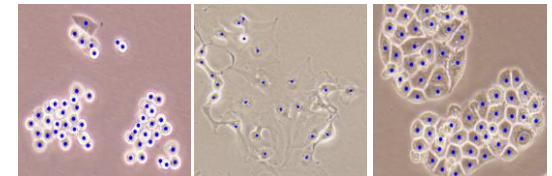
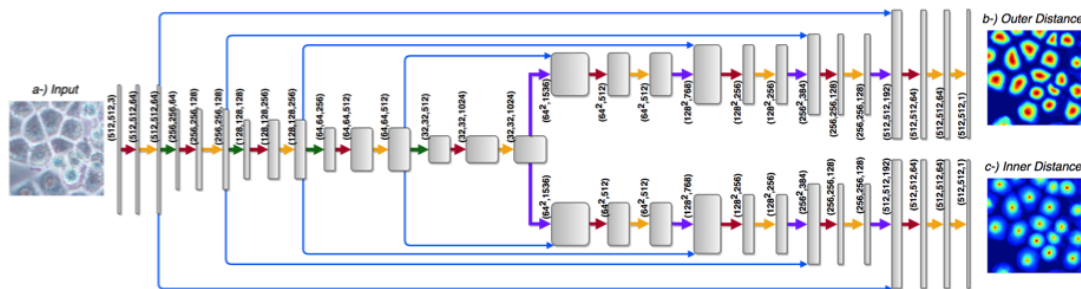
End-to-end gland and tissue segmentation using fully convolutional networks



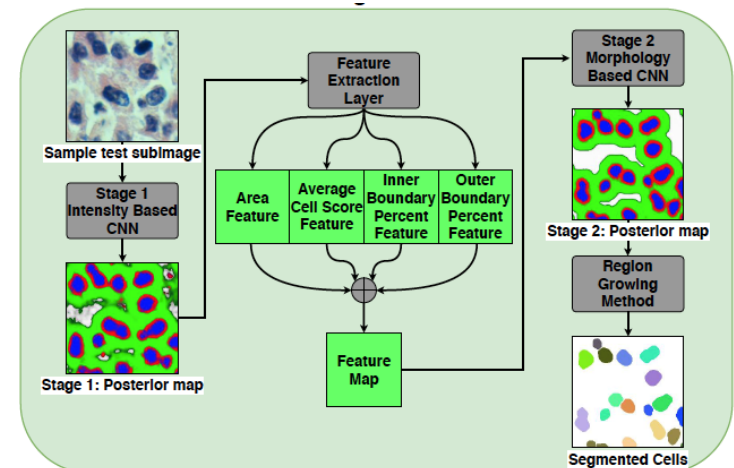
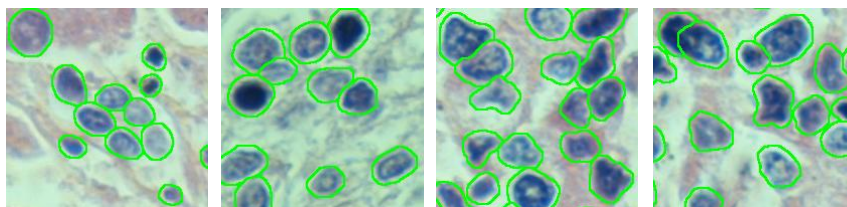
# Deep Learning for Medical Image Analysis

## Cell Segmentation

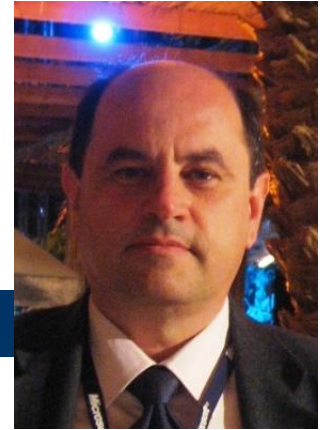
Multi-task models for cell detection in live cell microscopy



Two-stage convolutional neural networks for cell nucleus segmentation in tissue images



# Machine Learning and Data Mining



Current research topics include  
Learning to

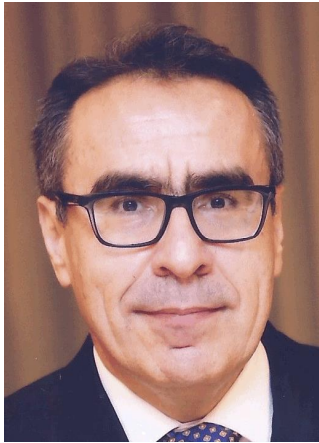
- rank instances
- model risk factors
- estimate risks
- suggest to increase success

Application areas: Medical, Social Networks



# Networks and Systems Research Group

<http://www.cs.bilkent.edu.tr/~korpe/nsrg/>



Faculty Member

**Ibrahim Korpeoglu**

*Professor*

*Dept of Computer Engineering  
Bilkent University*

Email: [korpe@cs.bilkent.edu.tr](mailto:korpe@cs.bilkent.edu.tr)

Web: <http://www.cs.bilkent.edu.tr>

Office: Engineering EA 401

Phone: 290 2599

## □ Research Areas:

- Computer Networks
- Wireless Networks
- Sensor Networks
- P2P Networks
- Computer Systems
- Distributed Systems
- Cloud Computing
- Internet of Things
- Big Data Systems

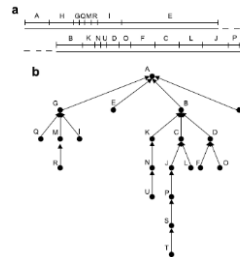
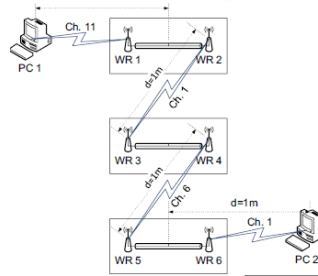
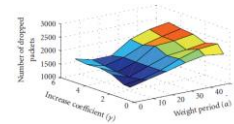
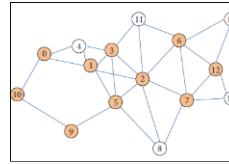
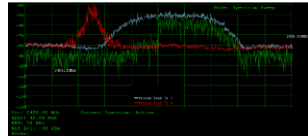
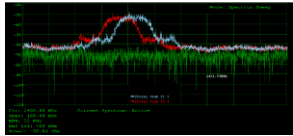
Working on Problems and Projects related with  
**Computer Networks and Computer Systems**

# Networks and Systems Research Group

## Sample Current Work

### Wireless Mesh Networks

- Routing
- Channel assignment
- Interference modeling
- Interference mitigation



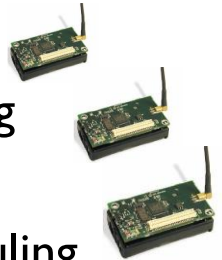
### Testbeds

### Cloud Computing

- Resource allocation
- VM placement
- Network virtualization
- Network embedding
- Mobile Edge Computing

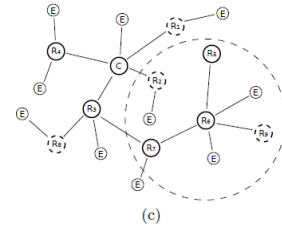
### Sensor Networks

- Energy efficient routing
- Activity scheduling
- Channel access scheduling
- ZigBee wireless technology
- ZigBee routing



### P2P Networks

- Query forwarding
- Free riding
- File sharing and lookup



### Internet of Things

- Data and Application Placement

# Networks and Systems Research Group

## Sample Funded Projects

- Efficient **Resource Allocation in Heterogeneous Cloud Infrastructures**  
*Sponsor: TUBITAK*
- Supporting Real-time Traffic in **Wireless Ad Hoc and Sensor Networks**  
*Sponsor: TUBITAK*
- *Bluetooth Scatternet Construction and Bluetooth Applications*  
*Sponsor: TUBITAK*
- Network Middleware for Environmental Monitoring and Control with **Wireless Ad hoc, Mesh and Sensor Networks**  
*Sponsor: IBM Corporation*
- Intel WCNC, **Wireless Networking** Curriculum Enhancement Project  
*Sponsor: Intel Corporation*
- FIRESENSE Fire Detection and Management through a **Multi-Sensor Network** for the Protection of Cultural Heritage Areas from the Risk of Fire and Extreme Weather Conditions  
*Sponsor: European Commission FP7 Programme, ENV*
- Network of Excellence in **Wireless Communications** (NEWCOM and NEWCOM++)  
*Sponsor: European Commission FP7 Programme, ICT*

# Networks and Systems Research Group

## Sample Publications

- Cem Mergenci, Ibrahim Korpeoglu, **Fly-path: Traffic-based Multi-hop Routing Approach for Hybrid Wireless Data Centers**, *Computer Communications*, vol.170, March 2021
- Fatih Deniz, Hakki Bagci, Ibrahim Korpeoglu, Adnan Yazici, **Energy-Efficient and Fault-Tolerant Drone-BS Placement in Heterogeneous Wireless Sensor Networks**, *Wireless Networks*, Springer, November 2020.
- Cem Mergenci, Ibrahim Korpeoglu, **Generic Resource Allocation Metrics and Methods for Heterogeneous Cloud Infrastructures**, *Journal of Network and Computer Applications*, Volume 146, November, 2019.
- Firat Karatas, Ibrahim Korpeoglu, **Fog-Based Data Distribution Service (F-DAD) for Internet of Things (IoT) Applications**, *Future Generation Computer Systems*, Volume 93, pages 156-169, April 2019. Hidayet Aksu, Ibrahim Korpeoglu, Ozgur Ulusoy, **An Analysis of Social Networks based on Tera-scale Telecommunication Datasets**, *IEEE Transactions on Emerging Topics in Computing*, Volume 7, Issue 2, pages 349-360, April-June 2019.
- Metin Tekkalmaz, Ibrahim Korpeoglu, **Distributed Power-Source-Aware Routing in Wireless Sensor Networks**, *ACM-Springer Wireless Networks Journal*, 22(4), pages 1381-1399, May 2016.
- Hakki Bagci, Ibrahim Korpeoglu, Adnan Yazici, **A Distributed Fault-Tolerant Topology Control Algorithm for Heterogeneous Wireless Sensor Networks**, *IEEE Transactions on Parallel and Distributed Systems*, 26(4), April 2015.
- Hidayet Aksu, Mustafa Canim, Yuan-Chi Chang, Ibrahim Korpeoglu, Ozgur Ulusoy, **Distributed k-Core View Materialization and Maintenance for Large Dynamic Graphs**, *IEEE Transactions on Knowledge and Data Engineering*, 26(10), pages 2439-2452, 2014.

More information at the group website: <http://www.cs.bilkent.edu.tr/~korpe/nsrg/>

# Özgür S. Ögüz

- Recently joined the CS department in January 2022.
- Office: EA529
- Phone: 2903398



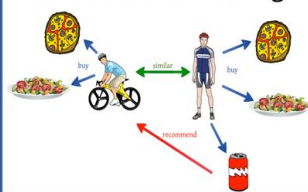
# Mustafa Ozdal

[www.cs.bilkent.edu.tr/~mustafa.ozdal](http://www.cs.bilkent.edu.tr/~mustafa.ozdal)

## High-Performance and Energy Efficient Computing

### *Algorithms, Systems, and Applications*

Collaborative Filtering



Graph Analytics



PageRank



Scientific Computing

$Y = \sum_{i=1}^n \lambda_i a_i^{(1)} \odot a_i^{(2)} \odot a_i^{(3)} + \epsilon$

•  $R_1 = R_2 = R_3 = I$   
•  $\odot$  is vector diagonal

FPGAs



GPUs



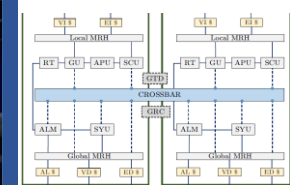
Xeon Phi



Parallel Systems



Novel Architectures





# Mustafa Ozdal

[www.cs.bilkent.edu.tr/~mustafa.ozdal](http://www.cs.bilkent.edu.tr/~mustafa.ozdal)

## Active projects:

- Energy efficient FPGA accelerators for big data applications (*supported by European Commission, in collaboration with Intel, Oregon*)
- Parallelizing Collaborative Filtering algorithms for recommender systems
- Parallel and vectorized scientific computing algorithms
- Optimizing memory architecture for graph analytics applications for large datasets.

I am interested in graduate student candidates who have one or more of the following:

- Strong algorithmic background and analytical skills
- Interest in solving programming puzzles
- C++ programming skills
- Experience with multi-core, GPU, and/or FPGA programming

For more information, see [www.bilkent.edu.tr/~mustafa.ozdal](http://www.bilkent.edu.tr/~mustafa.ozdal). You can send an email to [mustafa.ozdal@cs.bilkent.edu.tr](mailto:mustafa.ozdal@cs.bilkent.edu.tr) to set up an appointment.



# Özcan Öztürk

Office: EA 421 Phone: 290-3444

Email: [ozturk@cs.bilkent.edu.tr](mailto:ozturk@cs.bilkent.edu.tr)

URL: <http://www.cs.bilkent.edu.tr/~ozturk>



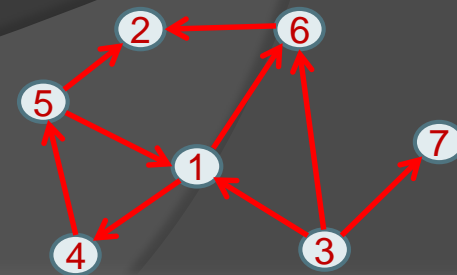
- ◉ **Computer architecture** - memory scheduling, memory hierarchy design, metrics to consider energy, performance, reliability....
- ◉ **Multicore/Manycore architecture** - design of multicore systems, application mapping, data mapping, communication
- ◉ **Heterogeneous computing** - heterogeneous multicore design, core and cache selection, application execution
- ◉ **Parallel programming/systems/applications** - OpenMP, MPI, GPGPU, application characterization, automatic parallelization, scheduling
- ◉ **Cloud computing** - at the system level and architectural optimizations, heterogeneity aware scheduling
- ◉ **Embedded computing** - energy, performance, ...
- ◉ **Compiler optimizations** - code modifications and optimizations to generate better applications



# Current Projects



- Heterogeneous Multicore Design  
*Funding: EC FP7*
- Parallelization for Heterogeneous Multicore Architectures  
*Funding: IBM*
- Utilizing Accelerator Technologies in the Cloud  
*Funding: Türk Telekom*
- Parallelizing Data Mining applications using GPUs  
*Funding: Nvidia*
- Accelerator Design for Graph Parallel Applications  
*Funding: Intel*



# Eray Tüzün

Bilkent University Software Engineering and Data Analytics Research Group

[eraytuzun@cs.bilkent.edu.tr](mailto:eraytuzun@cs.bilkent.edu.tr)

<http://www.cs.bilkent.edu.tr/~eraytuzun>

Office: EA-501



## Research Areas

- Software Analytics / Intelligence
- Machine Learning & Data Science for Software Engineering
- Software Product Line Engineering
- Gamification / Serious Games

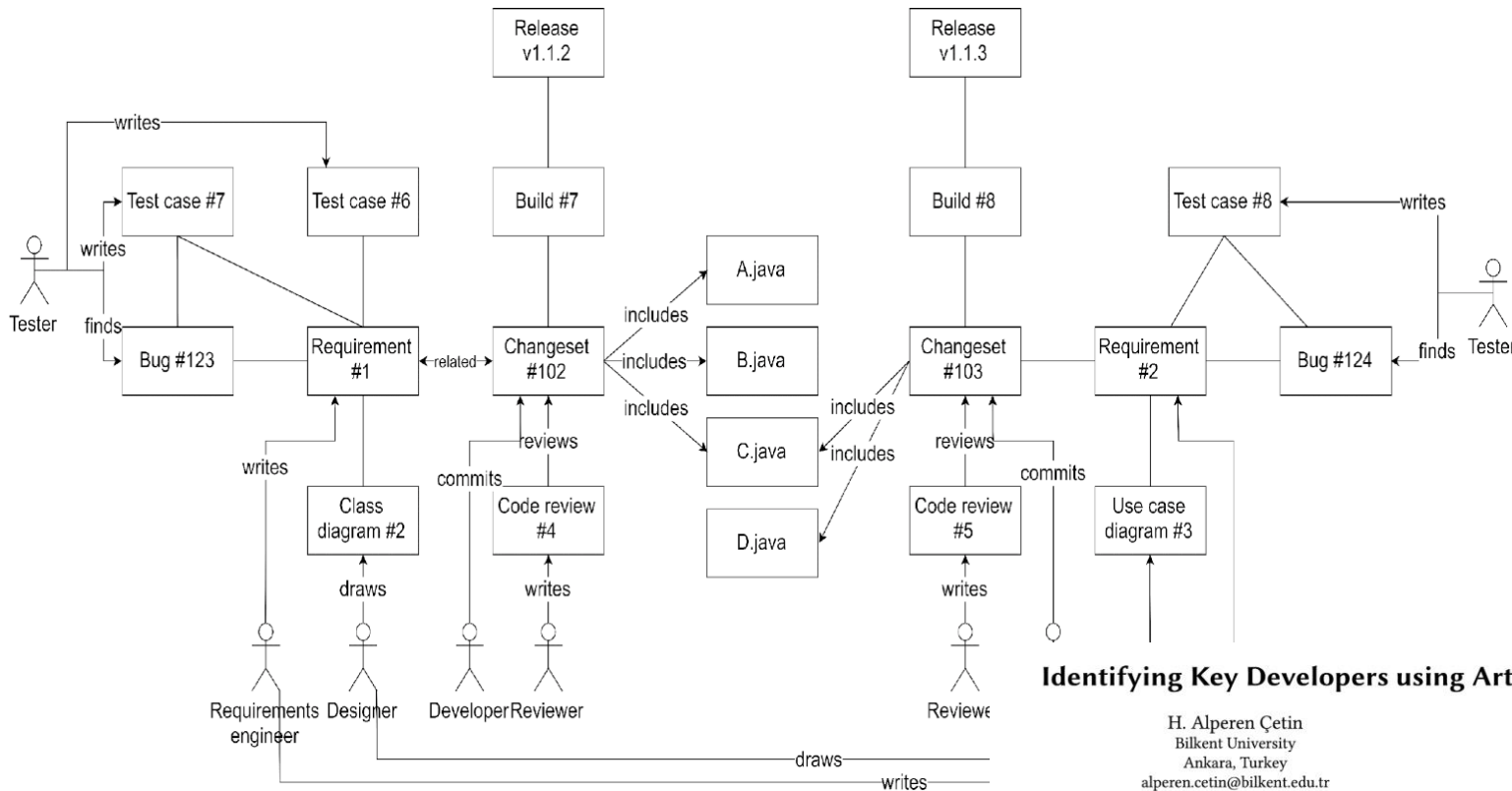
Interested in being part of our research group?

Please contact us at

[eraytuzun@cs.bilkent.edu.tr](mailto:eraytuzun@cs.bilkent.edu.tr)



# Mining Software Engineering data



## Identifying Key Developers using Artifact Traceability Graphs

H. Alperen Cetin  
Bilkent University  
Ankara, Turkey  
alperen.cetin@bilkent.edu.tr

Eray Tüzün  
Bilkent University  
Ankara, Turkey  
eraytuzun@cs.bilkent.edu.tr

## Analyzing Developer Contributions using Artifact Traceability Graphs

H. Alperen Cetin, Eray Tuzun  
Bilkent University  
Ankara, Turkey

### ABSTRACT

Developers are the most important resource to build and maintain software projects. Due to various reasons, some developers take more responsibility, and this type of developers are more valuable and indispensable for the project. Without them, the success of the project would be at risk. We use the term *key developers* for

### 1 INTRODUCTION

Software development mainly depends on human effort. In a project, some developers take more responsibility, and the success rate of the project heavily depends on these developers. Thus, they are valuable and essential to develop and maintain the project, in other words, they are the *key developers* of the project.

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### Abstract

Software artifacts are the by-products of the development process. Throughout the life cycle of a project, developers produce different artifacts such as source files and bug reports. To analyze developer contributions, we construct artifact traceability graphs with these artifacts and their relations using the data from software development and collaboration tools.

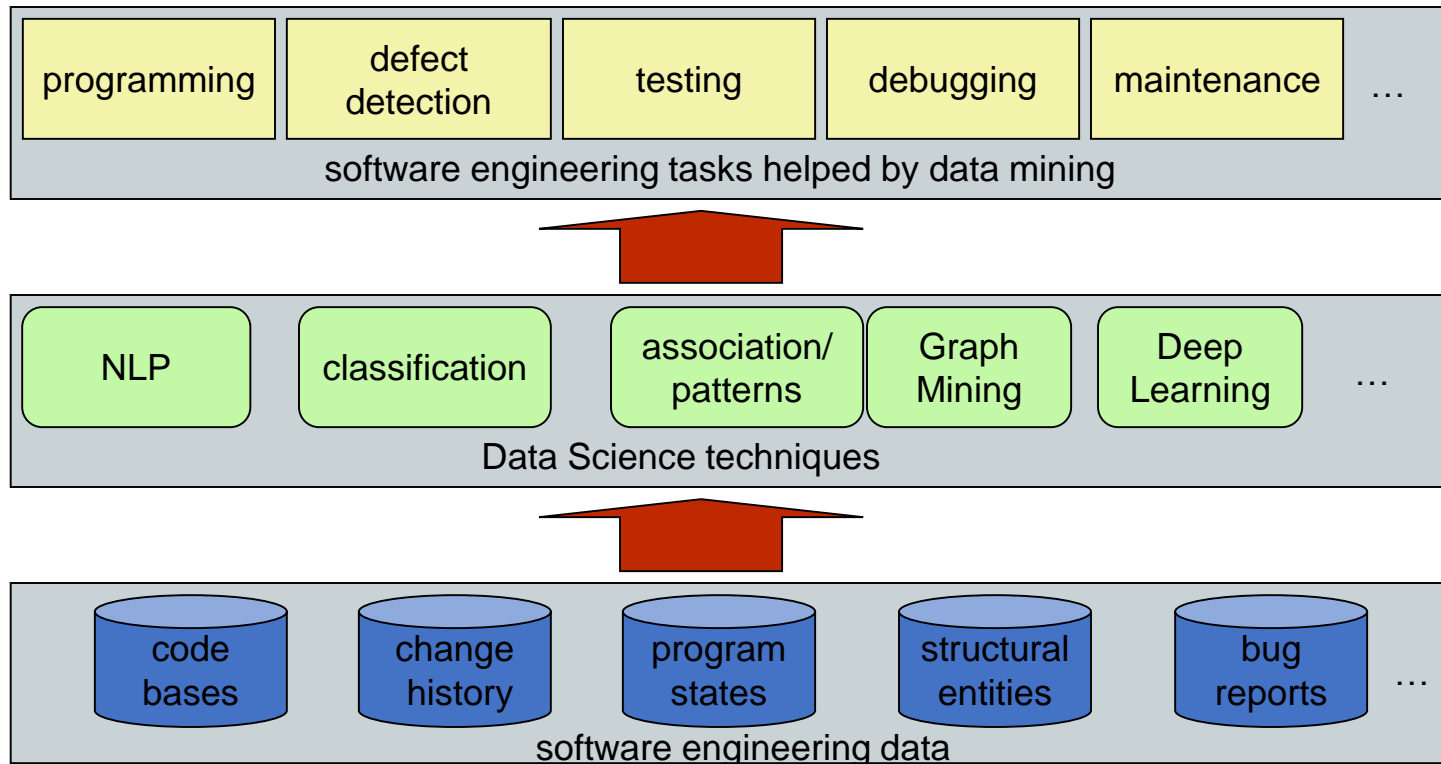
## RSTrace+: Reviewer suggestion using software artifact traceability graphs

Emre Sülün\*, Eray Tüzün, Uğur Doğrusöz

Department of Computer Engineering, Bilkent University, Ankara, Turkey

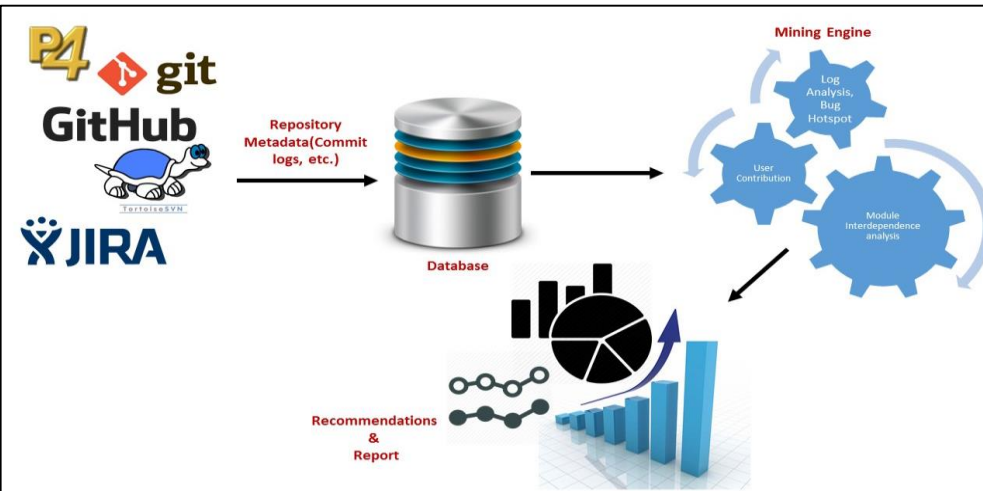


# Overview of Data Science in SE





# Software Analytics & Software Productivity

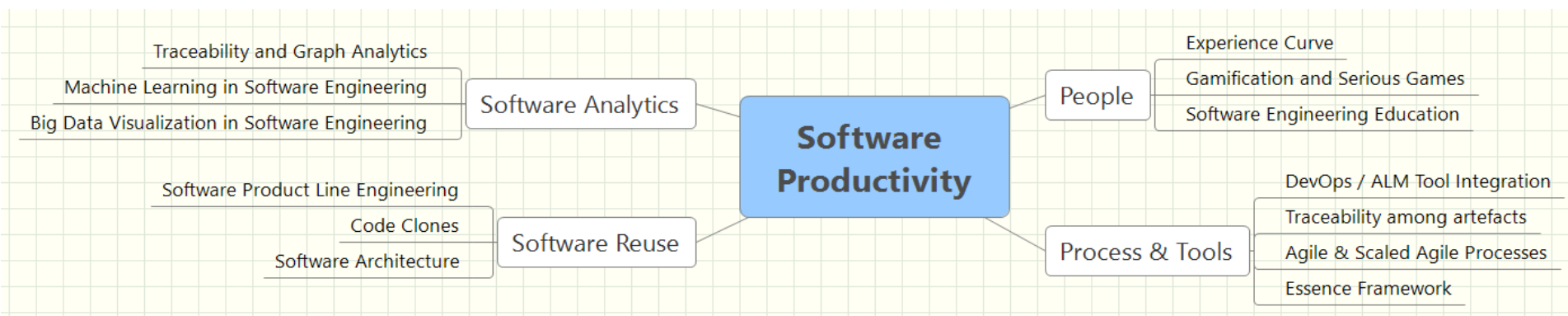


"practice offering software practitioners (not just developer) up-to-date and pertinent information to support their daily decision-making processes and Software Intelligence should support decision-making processes throughout the lifetime of a software system"

Ahmed E. Hassan and Tao Xie

Guess the location of undetected bugs  
Who should fix this bug?  
Who should review this pull request?  
Which files are more likely to be buggy?

...



# Recent Publications

- Ground Truth Deficiencies in Software Engineering: When codifying the past is counterproductive. Eray Tüzün, Hakan Erdoğan, Maria Teresa Baldassare, Michael Felderer, Robert Feldt, Burak Turhan. *IEEE Software*, 2021
- What makes Agile Software Development Agile? HELENA Consortium. *IEEE Transactions on Software Engineering*, 2021
- RSTrace+: Reviewer Suggestion using Software Artifact Traceability Graphs. Emre Sülün, Uğur Doğrusöz, Eray Tüzün. *Information and Software Technology*, 2021
- Bus Factor In Practice. E Jabrayilzade, M Evtikhiev, E Tüzün, V Kovalenko, 44<sup>th</sup> International Conference on Software Engineering, 2022
- Bug Tracking Process Smells in Practice. Erdem Tuna, Vladimir Kovalenko, Eray Tüzün, 44th International Conference on Software Engineering, 2022
- Analyzing Developer Contributions using Artifact Traceability Graphs. Alperen Çetin, Eray Tüzün. *Empirical Software Engineering*, 2022
- [Closing the gap between software engineering education and industrial needs](#), Vahid Garousi, Görkem Giray, Eray Tüzün, Cagatay Catal, Michael Felderer , *IEEE Software*, 2020
- Identifying Key Developers using Artifact Traceability Graphs. Alperen Cetin, Eray Tüzün. *PROMISE*, 2020
- [Towards a taxonomy of code review smells](#), Emre Dogan, Eray Tüzün, *Information Software and Technology*, 2021



**BILSEN**

HOME RESEARCH

Bilkent University Software Engineering and Data Analytics Research Group



**BILSEN (Bilkent University Software Engineering and Data Analytics Research Group)** of [Computer Engineering Department](#) at [Bilkent University](#) has been performing research studies on software engineering domain over the last decade.

## Bilkent University Software Engineering and Data Analytics Research Group (BILSEN)

<https://bilsengroup.github.io>

### Graduate Students

- Barış Ardiç, MSc
- Utku Ünal, MSc (METU)
- Shirin Pirouzkhah, MSc
- Khushbakht Ali, MSc
- Emre Sülün, MSc
- Elgun Jabrayilzade, MSc
- Erdem Tuna, MSc

Interested in being part of our research group?  
Please contact us at  
[eraytuzun@cs.bilkent.edu.tr](mailto:eraytuzun@cs.bilkent.edu.tr)



@eraytuzun

<http://twitter.com/eraytuzun>



# Data Science Research

Özgür Ulusoy

<http://www.cs.bilkent.edu.tr/~oulusoy/>

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- **Text-to-SQL Systems**
- **Web Search Engines**
- **Multimedia Database Systems**
- **Social Network Analysis**



# Text-to-SQL Systems

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- **Keyword Mapping**
- **Explainable Text-to-SQL**
- **Query Recommendation**



# Text-to-SQL Systems

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**Keyword Mapping** - mapping between tokens in the query and relational database elements

- ❖ Keyword mapping formulated as sequence tagging problem in NLP
- ❖ An end-to-end keyword mapper (DBTagger)





# Text-to-SQL Systems

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## **Explainable Text-to-SQL** - based on Explainable AI

- ❖ Explaining the decisions made by the keyword mapping system using LIME
- ❖ A novel wrapper around LIME
- ❖ Using a schema graph to explain join-path inference

# Text-to-SQL Systems

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## Query Recommendation

- ❖ A ranking method to create a list of suggested queries
- ❖ Distributed representations for database tuples, trained on a relational database
- ❖ Graph convolutional networks (GCNs) to learn distributed representations



# Web Search Engines

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- **Learning to Rank for Educational Web Search**
- **Diversification of Search Results**
- **Efficiency and Scalability Issues for Web-IR**

**<http://www.cs.bilkent.edu.tr/~bilweb>**



# Web Search Engines

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## Learning to Rank for Educational Web Search - machine-learned ranking models

- ❖ A rich set of features employed in educational search
- ❖ Domain knowledge utilized to build query-dependent ranking models



# Web Search Engines

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## Diversification of Search Results

- ❖ Multidimensional result diversification
- ❖ Supervised learning methods for search result diversification
- ❖ Impact of index pruning on diversification performance





# Web Search Engines

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## Efficiency and Scalability Issues

- ❖ **Methods and algorithms for caching, indexing, and query processing in search engines**



# Multimedia Databases

(joint work with Prof. Uğur Gündükbay)

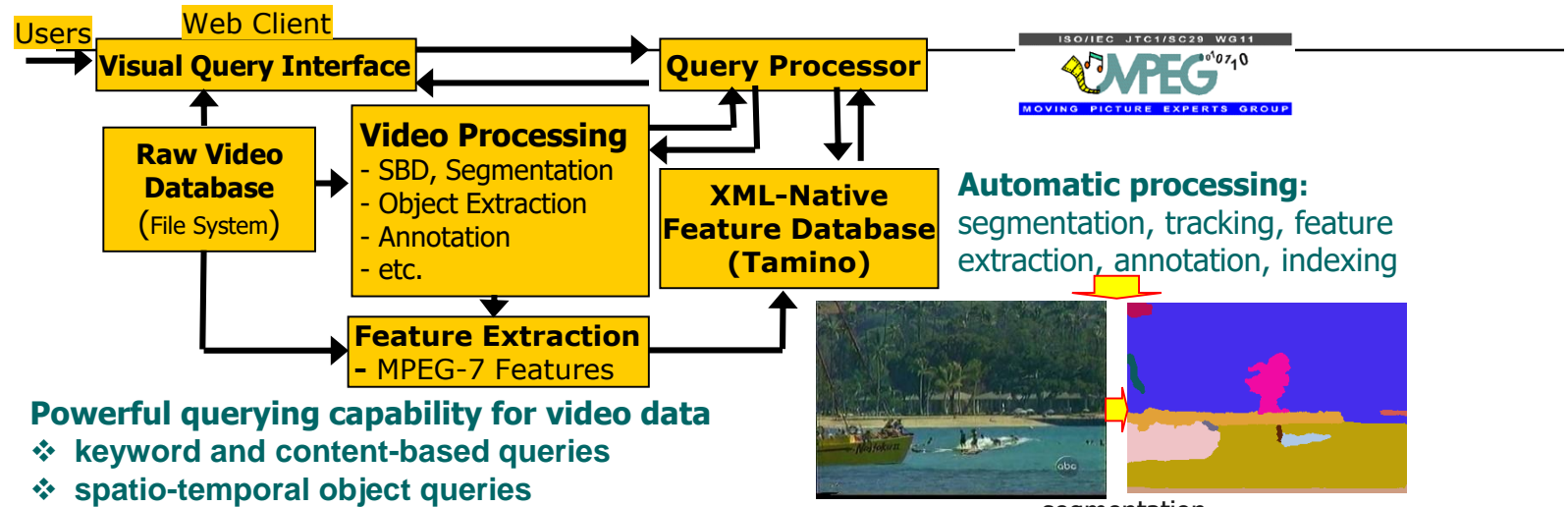
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- **Video Retrieval Systems**
- **Mobile Visual Search**
- **Learning Visual Similarity for Image Retrieval**

**<http://www.cs.bilkent.edu.tr/~bilmdg>**

# Multimedia Databases

## BilVideo-7: An MPEG-7 Compatible Video Retrieval System

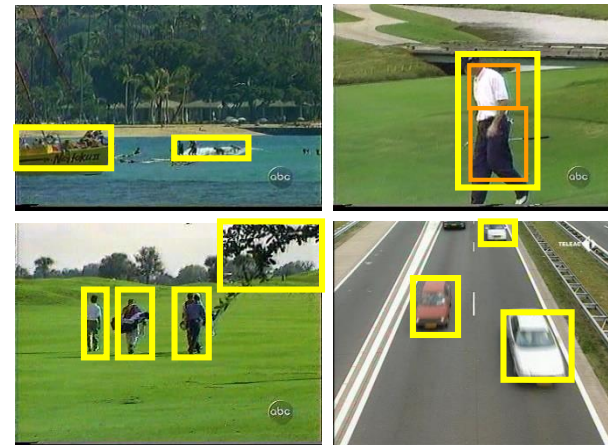


segmentation



keywords: trees, greenery, sky – bush, putin, dog

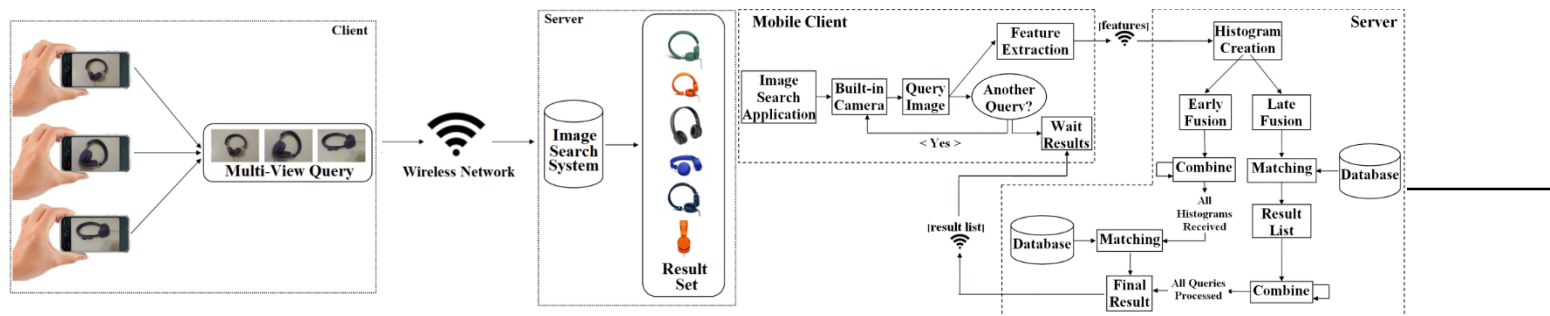
Example query formulation



Salient video object extraction

# Multimedia Databases

## Mobile Image Search Using Multi-View Object Image Queries



Dataset Images



Query Images

a)



QUERY

b)



QUERY LIST

c)



QUERY LIST



RESULT LIST



RESULT LIST

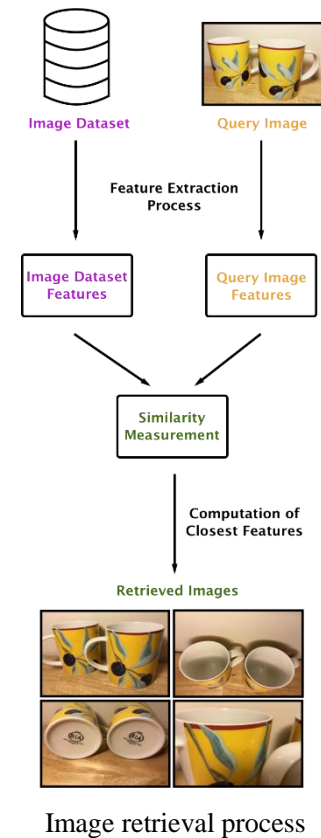
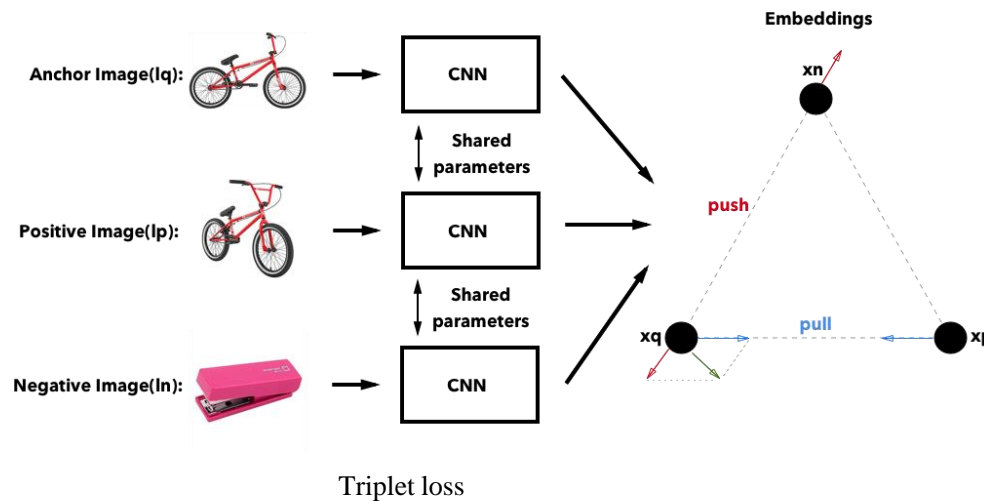


RESULT LIST

# Multimedia Databases

## Learning Visual Similarity for Image Retrieval with CNNs

- ❖ Learning efficient visual similarity for image retrieval by revealing resemblances and differences between product images







# Social Network Analysis

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- **Misinformation Propagation in Social Networks**
- **Social Network Data Analysis on Big Data Processing Platforms**



# Social Network Analysis

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## Misinformation Propagation in Social Networks

- ❖ Misinformation problem modelled as a game based on the notion of cooperative games
- ❖ Agents defined to maximize the total reward
- ❖ A blockchain - machine learning hybrid approach for addressing misinformation in a crowdsourced environment



# Social Network Analysis

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## Social Network Data Analysis on Big Data Processing Platforms

(joint work with Prof. İbrahim Körpeoğlu)

- ❖ **Community detection formulated as a multi-k-core problem**
- ❖ **Distributed multi-k-core construction and maintenance algorithms running on a big data platform**