Bilkent University
Computer Engineering Department

MSc and PhD Programs

Prof. Dr. H. Altay Güvenir

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, performance evaluation, scientific computing, virtual reality.

Applications

- Application Deadlines:
  Early: March 26, 2019; Regular: June 10, 2019
- Online Application: https://stars.bilkent.edu.tr/gradapp/
- Requirements for application:
  - CGPA ≥ 2.80 / 4.00
  - ALES (Turkish citizens) or GRE (Foreign applicants)
    - ALES: Quantitative ≥ 55 (for MS), 80 (for PhD w/o BS)
    - GRE: Quantitative ≥ 153 (MS), 157 (PhD)
  - English Proficiency: TOEFL (IBT) ≥ 87 or IELTS avg ≥ 6.5 (and min 5.5 in each section)
  - And YDS ≥ 55 (for Turkish citizen applying PhD).

Interview

- Date: April 15, 2019; June 27-28, 2019
- If not uploaded during online application, hard copy documents to be submitted during interview:
  - Transcript
  - ALES or GRE score report
  - Proof of English Proficiency (TOFLE, IELTS or YDS report)

Acceptance requirements

- At least one faculty member willing to work with the applicant towards thesis
- Department approval
- Graduate School of Engineering and Science approval

Scholarship Options

- Department scholarship
  - Tuition waiver
  - Stipend
  - Accommodation support
  - Health Insurance
  - Additional Scholarship for Teaching Assistantship
  - Office (shared)
- TÜBİTAK Scholarship or TÜBİTAK projects
  - Tuition waiver
  - Accommodation
  - Health Insurance
  - Office (shared)

Scholarship Options

- Project grants (other than TÜBİTAK projects)
  - Tuition waiver
  - Stipend (paid from the project budget)
  - Accommodation
  - Health Insurance (paid from the project budget)
  - Additional Scholarship for Teaching Assistantship
  - Office (shared)
- Graduate School scholarship
  - Tuition waiver
  - Additional Scholarship for Teaching Assistantship

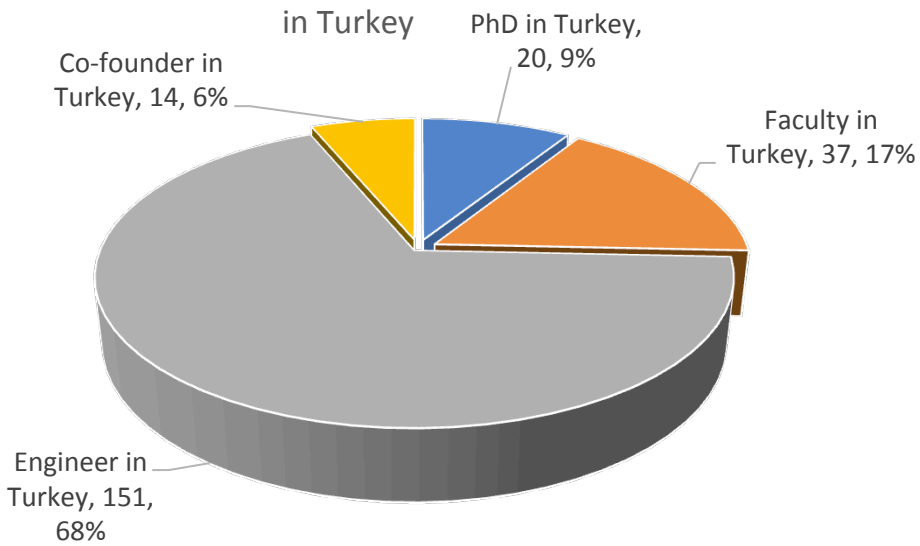
Degree Requirements

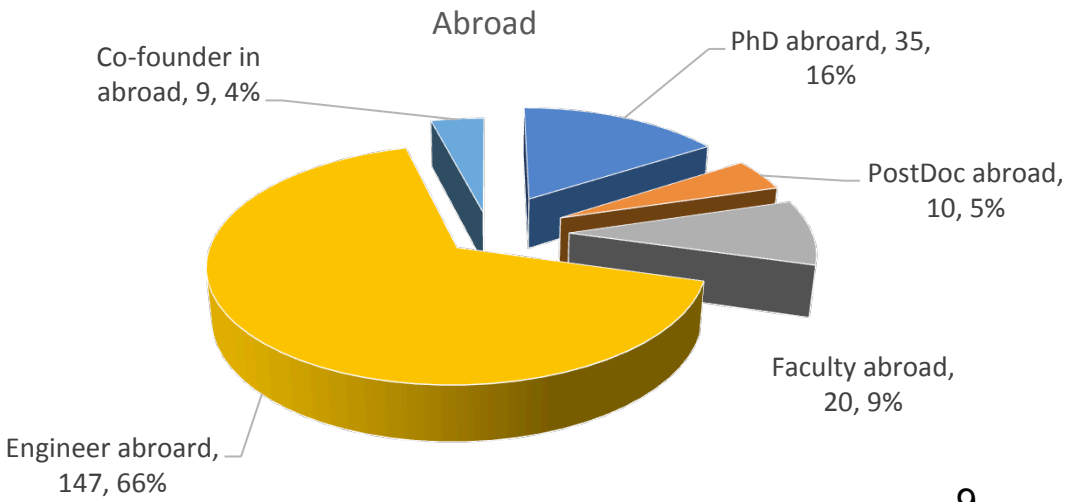
- MSc
  - 7 technical elective courses + Seminar +
    MS Thesis +
    Research Methods and Academic Publication Ethics course
- PhD
  - 7 technical elective courses + Seminar +
    Qual Exam + PhD Thesis + Journal Publication
    Research Methods and Academic Publication Ethics course

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 abroard	147	30.6%
Co-founder in abroad	9	4.1%
Unknown	37	7.7%

İn Turkey	222	46.3%
Abroard	221	46.0%
Unknown	37	7.7%
Total:	480	100.0%





Graduates of MS Program

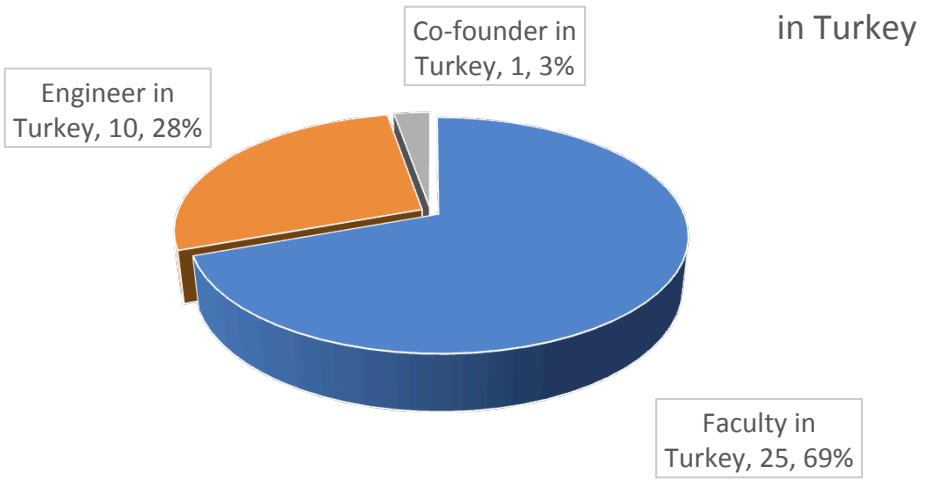
in Turkey	
Bilkent Univ.	25
ASELSAN	20
HAVELSAN	16
TÜBİTAK	13
Hacettepe Univ.	6
METU	6
TSK	5
STM	4
TCMB	4
Vestel	4
Cybersoft	3
Garanti Teknoloji	3
MilSOFT	3
OpsGenie	3
Sabancı Univ.	3
Akdeniz Univ.	2
Oracle	2

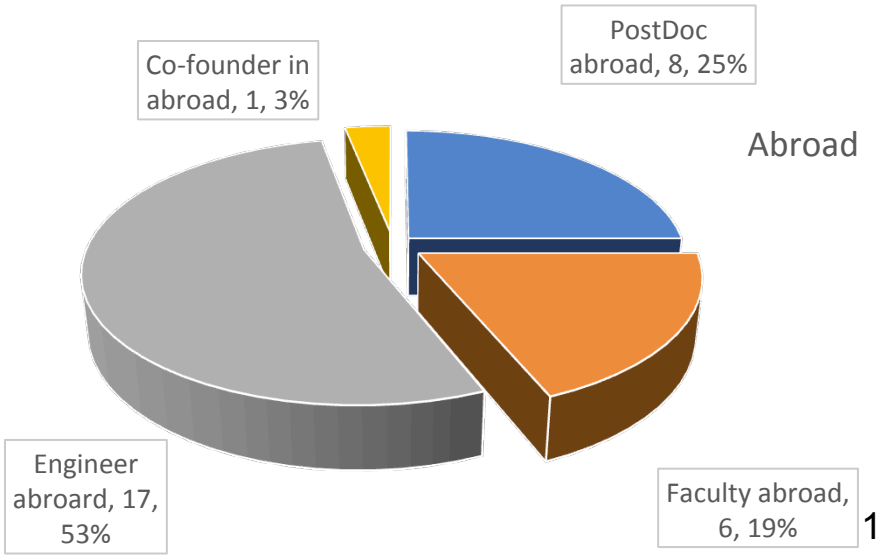
Abroad	
Microsoft	23
Google	16
Amazon	6
Booking.com	4
Case Western Reserve Univ.	4
Facebook	4
Univ. California	4
SAP	3
U. of Massachusetts Amherst	3
UBER	3
EPFL	2
ETH	2
Imperial College	2
Sandia National Labs.	2
U. of Texas at San Antonio	2
University of Florida	2
University of Waterloo	2
U. of Illinois 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 abroard	17	53.1%
Co-founder in abroad	1	3.1%

İn Turkey	36	52.9%
Abroard	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 alphabetic order

  (Please contact with them in person for details.)

VAROL AKMAN

- http://www.cs.bilkent.edu.tr/~akman
- email: akman@bilkent.edu.tr

My current research is two pronged:

i. contextual reasoning in AI
ii. public implications of the Internet

Contextual reasoning in AI

Problems originating from natural language processing and understanding, especially those caused by the lack of explicit context:

> When we say a particular thing, we do so in a context. Thus, there are embedded background assumptions available only through the context. We are also good at shifting between contexts. Can context be formalized in a formal framework? This would lead to improved software not only in Natural Language Understanding but also in knowledge-based systems, robotics, search engines, and personal assistants like Siri, Cortana, OK Google.

My grad courses CS 563 and CS 661 examine contexts, as well as other AI topics.

Public implications of the Internet

Problems caused by tensions between local versus global, individual versus corporate, and democratic versus authoritarian in the framework of the Internet. More specifically:

> Basic concepts and history of the Internet as a socio-political medium. Free access to information in the networked world. The Internet as a trusted communications medium in light of security and privacy issues. Censorship and politics of the Internet vis-à-vis interventions by oppressive governments. Social movements in the 21st century marked by rapid broadcast of ideas and images.

My grad course CS 513 treats such societal aspects of the Internet.

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

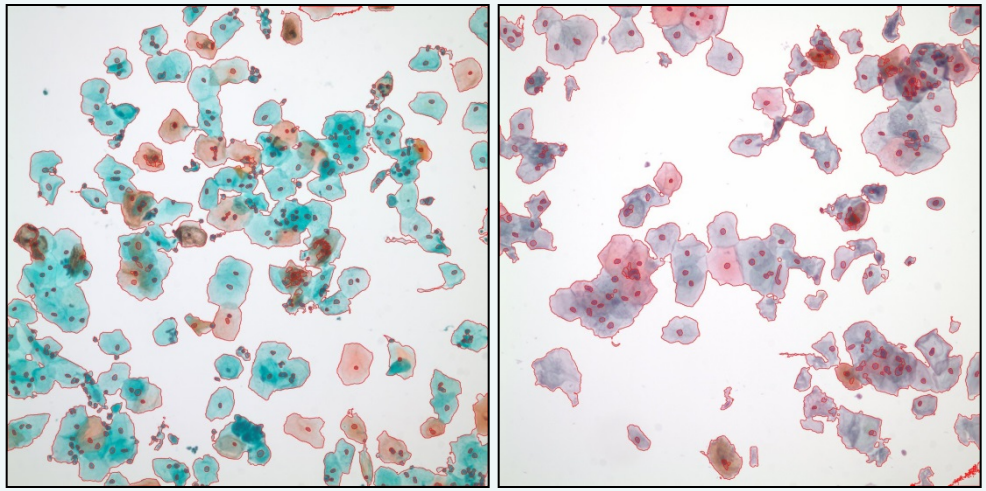
Current topics:

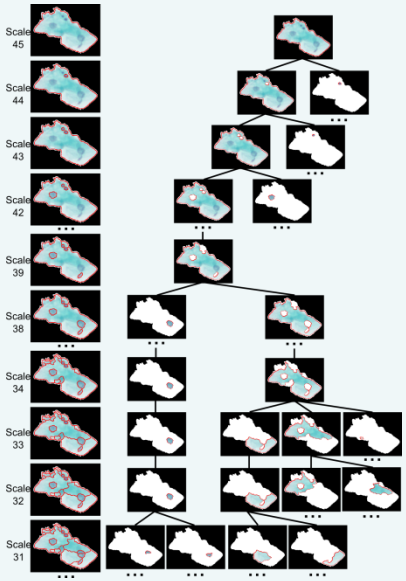
- Medical image analysis
- Remote sensing image analysis
- Image classification
- Object recognition
- Content-based image retrieval

Sponsored Research Projects

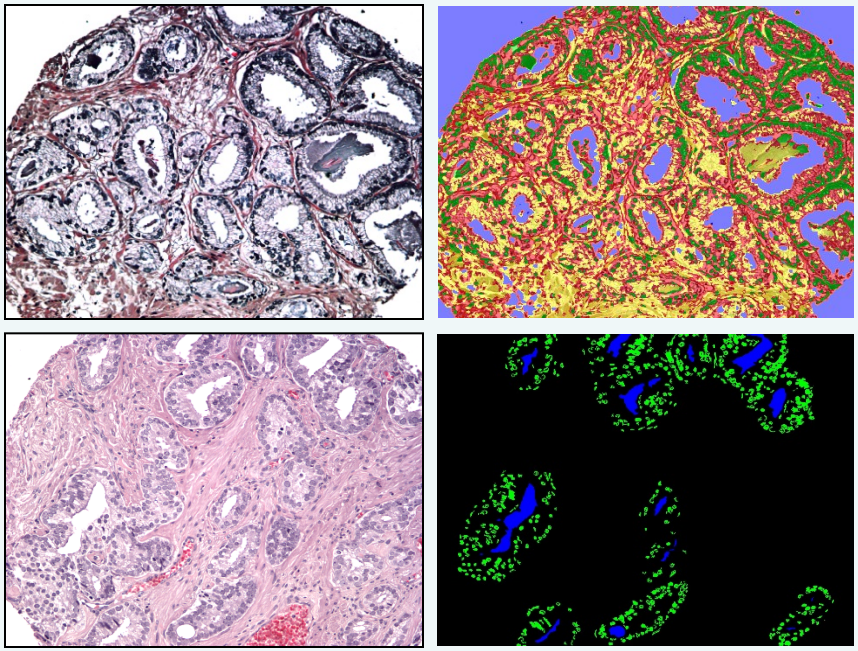
- Medical image analysis
  - TÜBİTAK 1001, 2018-2021
  - TÜBİTAK 1001, 2014-2017
  - TÜBİTAK CAREER Grant, 2005-2010
- Remote sensing image analysis
  - TÜBİTAK 1001, 2010-2012
  - European Commission, Joint Research Centre, 2008-2009
  - TÜBİTAK CAREER Grant, 2005-2010
  - FP6 Marie Curie Grant, 2005-2007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

Medical Image Analysis

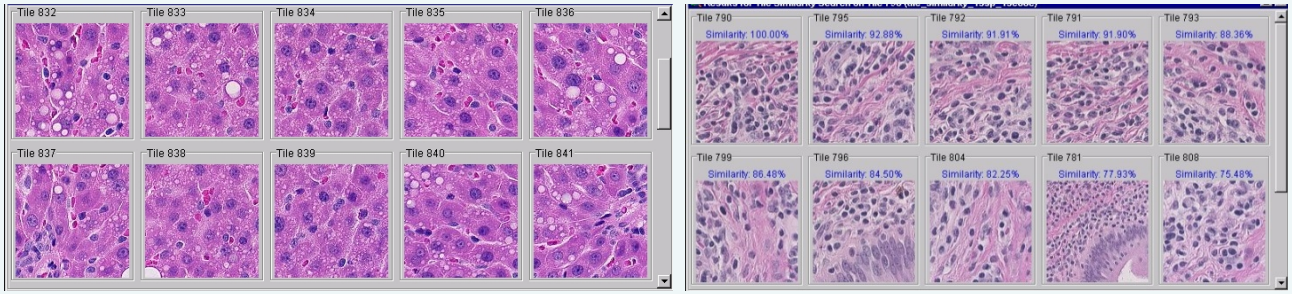




Segmentation and classification of cervical cells



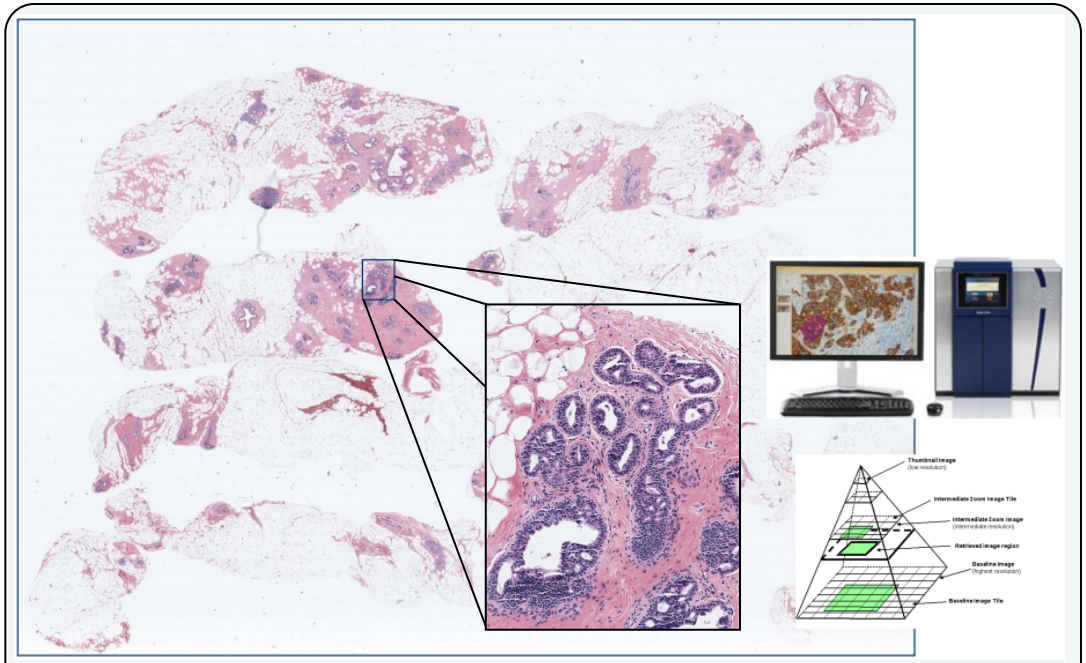
Classification of prostate biopsies



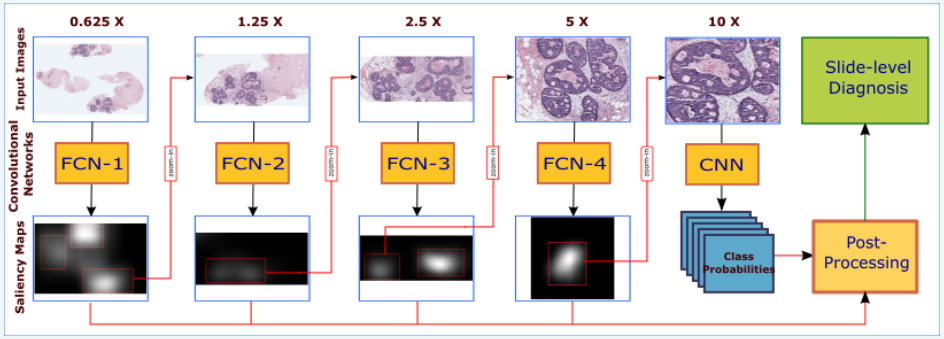
Content-based search of medical archives

Dr. Selim Aksoy

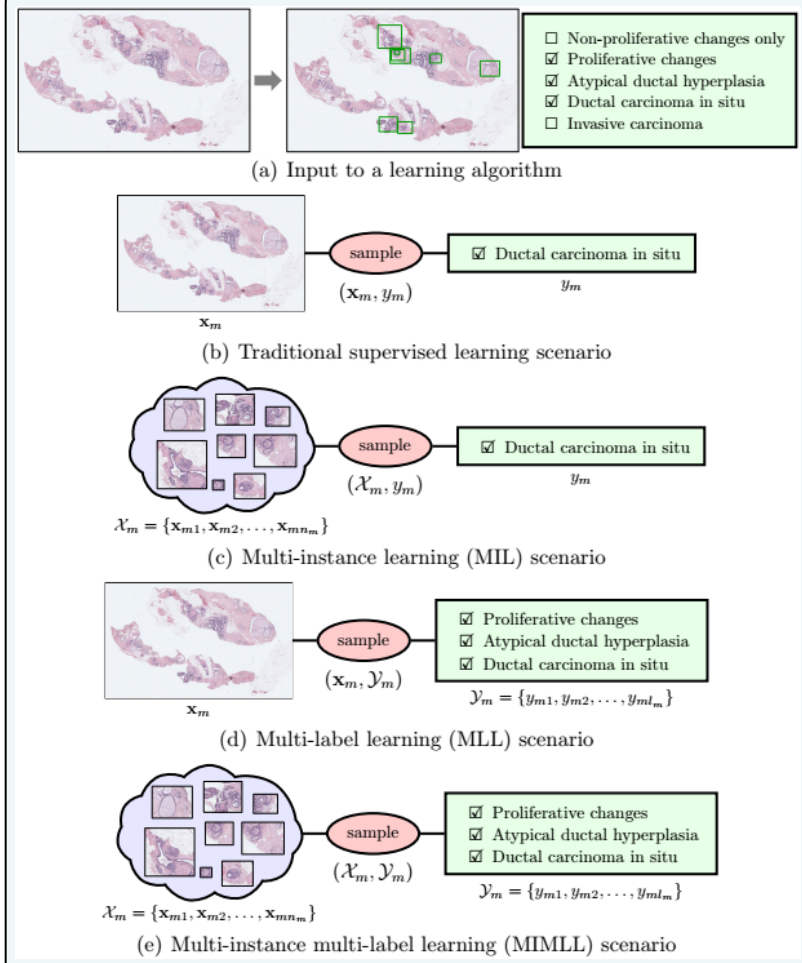
Medical Image Analysis



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



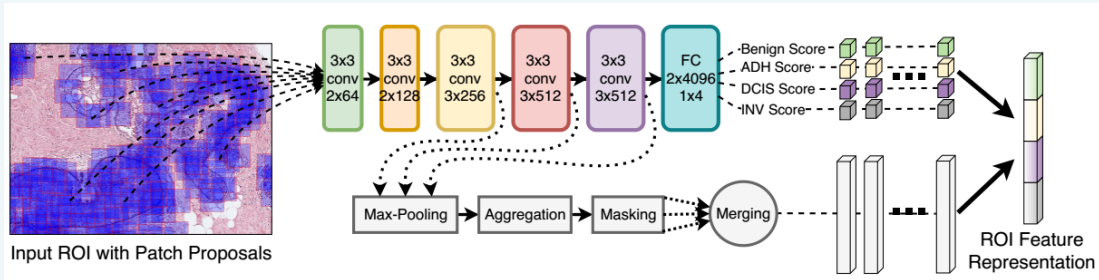
Deep networks for region of interest detection



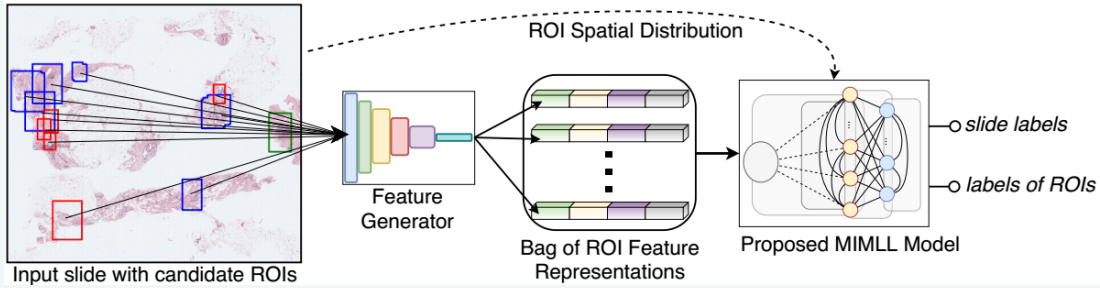
Different weakly supervised learning scenarios

Dr. Selim Aksoy

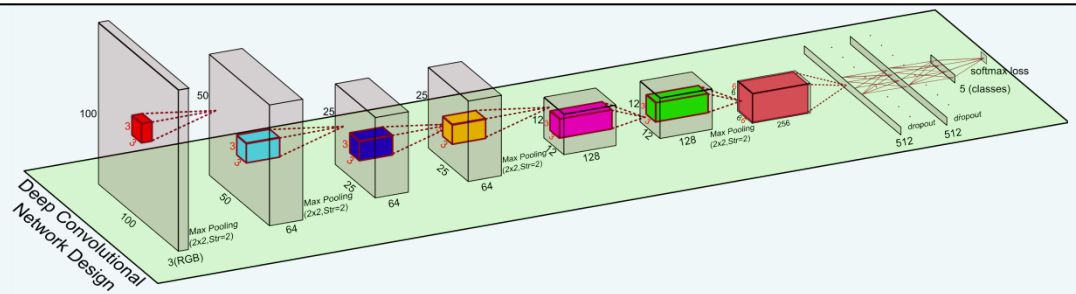
Medical Image Analysis



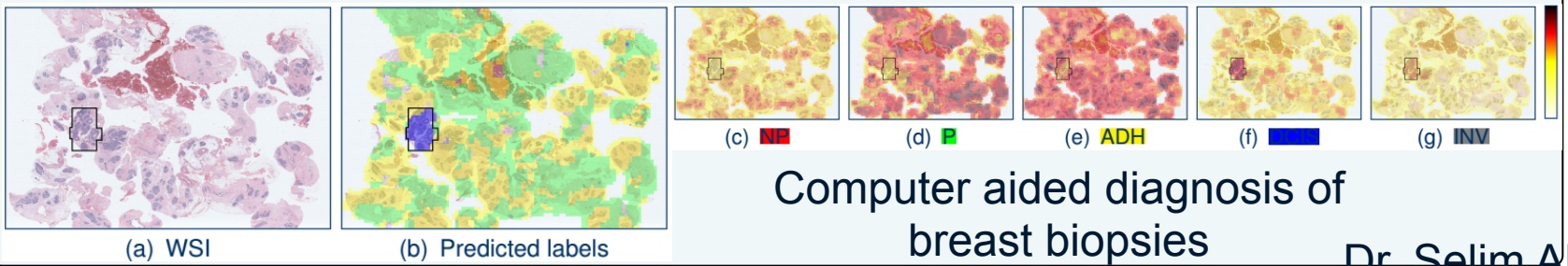
Deep feature representations



Conditional random fields for weakly supervised learning



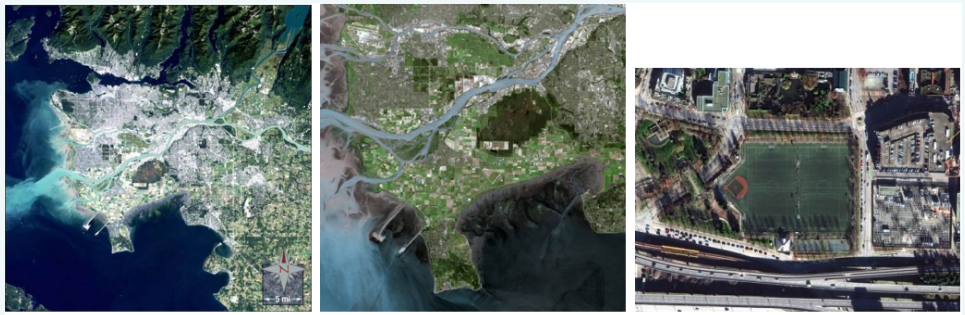
Convolutional neural networks for region of interest classification



Computer aided diagnosis of breast biopsies

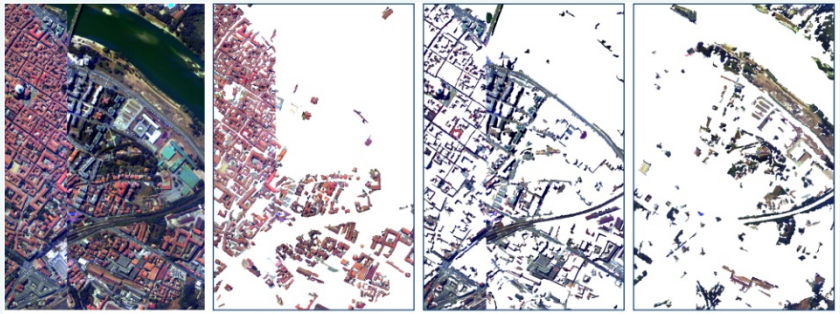
Dr. Selim Aksoy

Remote Sensing Image Analysis



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

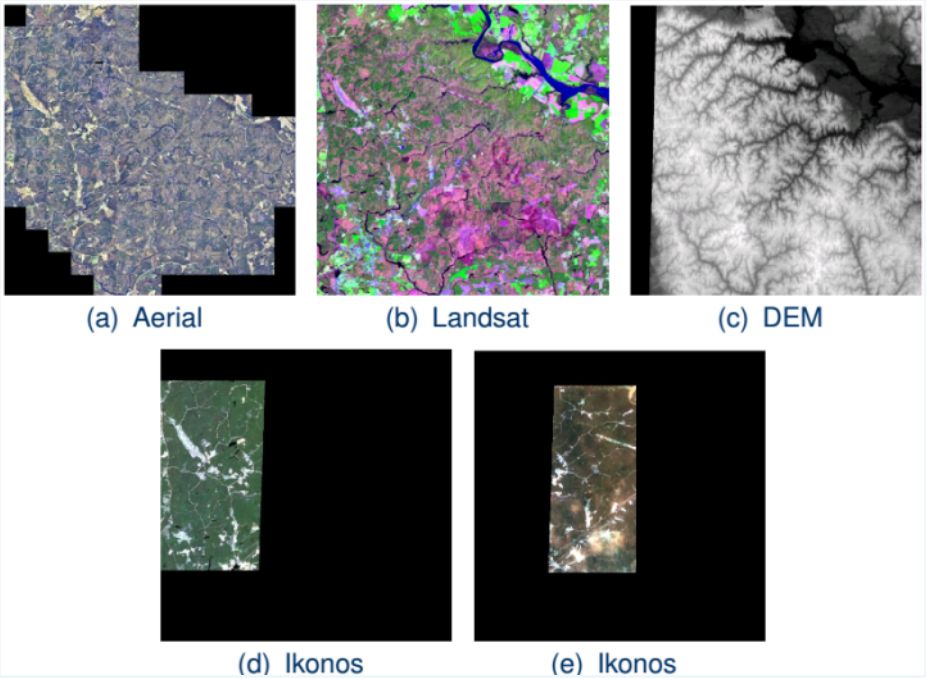
Increasing spatial resolution (300m ⇨ 1-2cm)



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

Hyperspectral image analysis

Orchard segmentation and agricultural mapping



(a) Aerial (b) Landsat (c) DEM

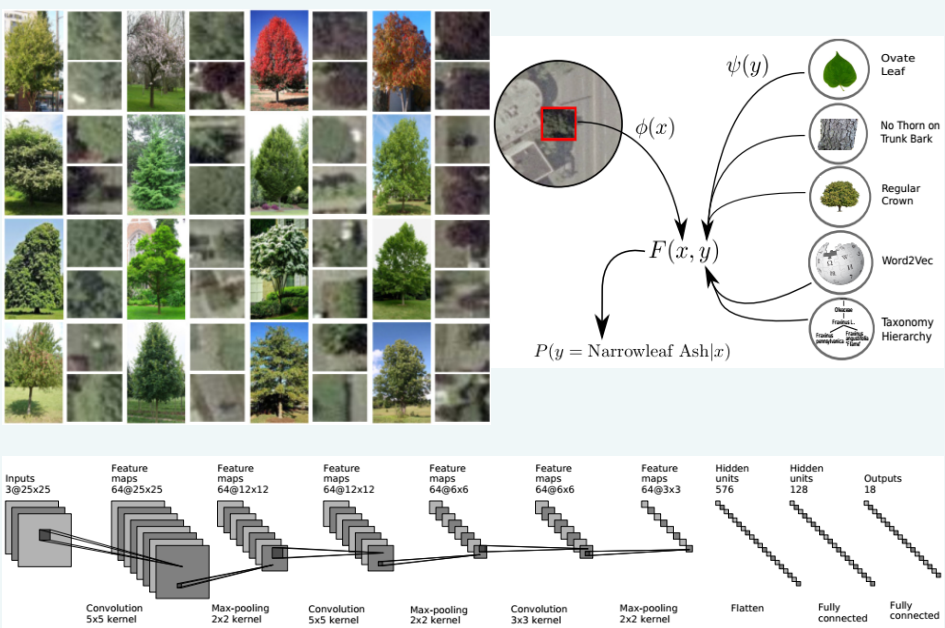
(d) Ikonos (e) Ikonos

Multi-source fusion and missing data analysis

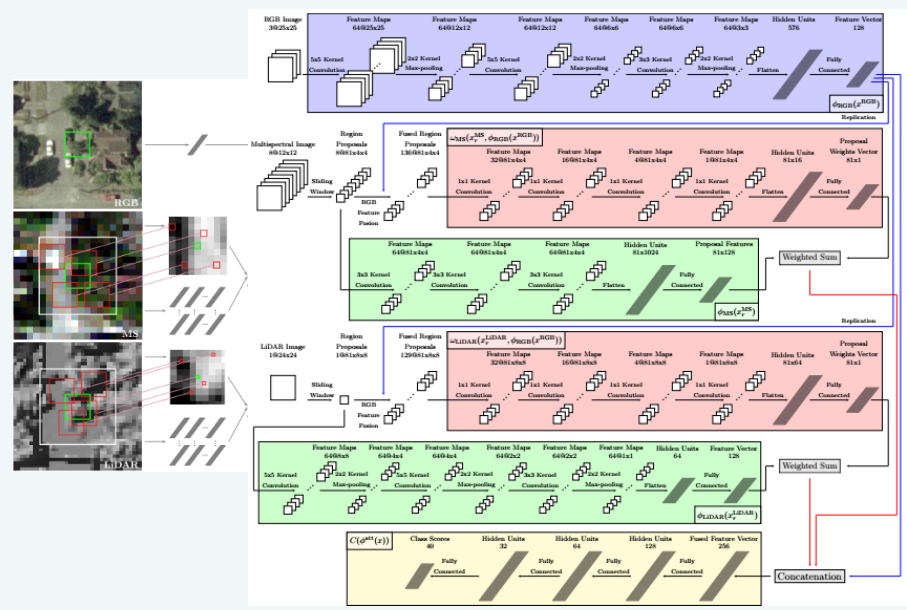
Dr. Selim Aksoy

Remote Sensing Image Analysis

Geospatial data mining



Zero-shot learning for object recognition



Attention model for multi-source fine-grained object recognition

Dr. Selim Aksoy

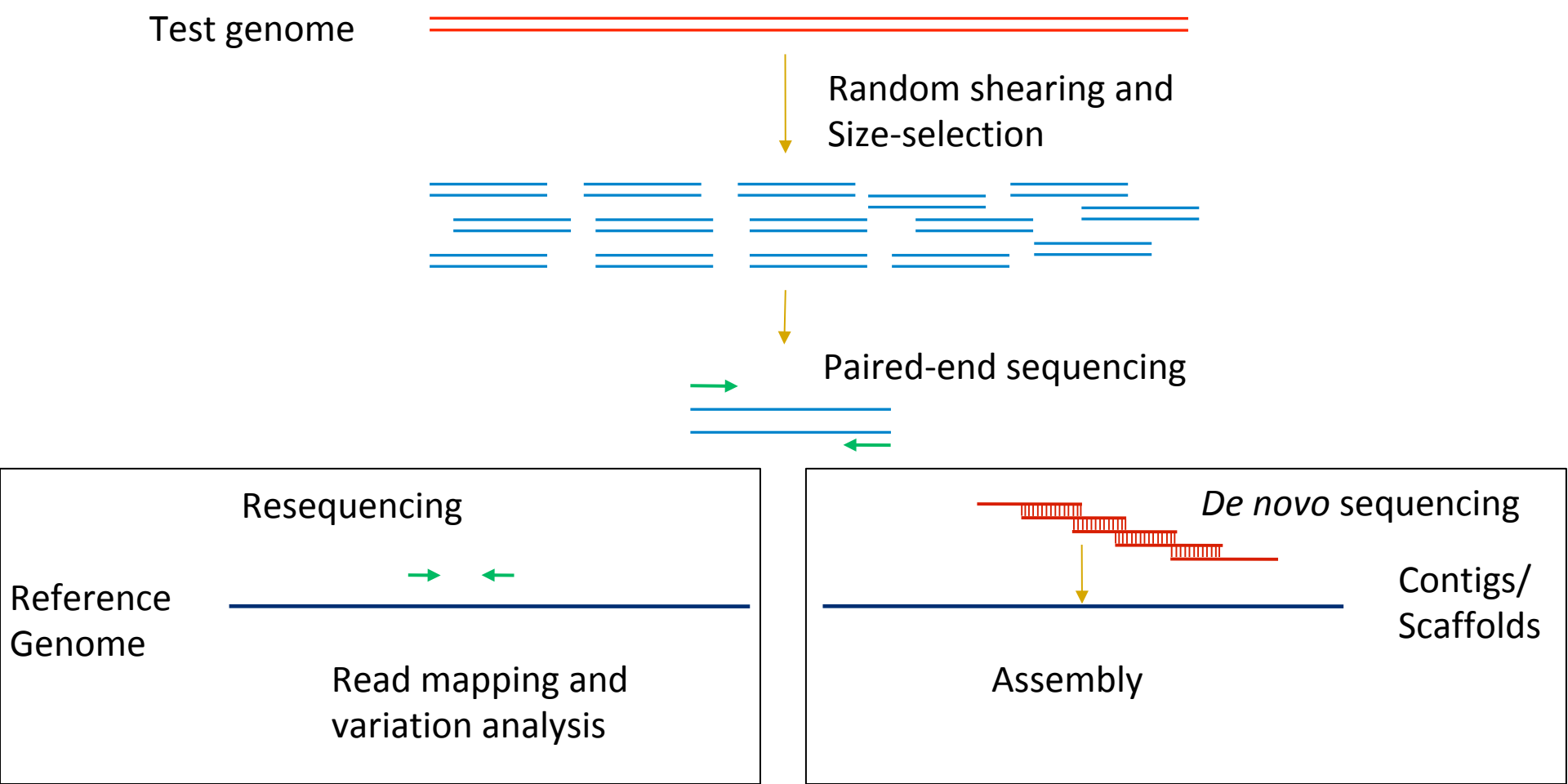
Can Alkan

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.



Types of genomic variants

SNP: Single nucleotide polymorphism (substitutions)
Indel: Insertions and deletions of sequence of length 1 to 50 basepairs

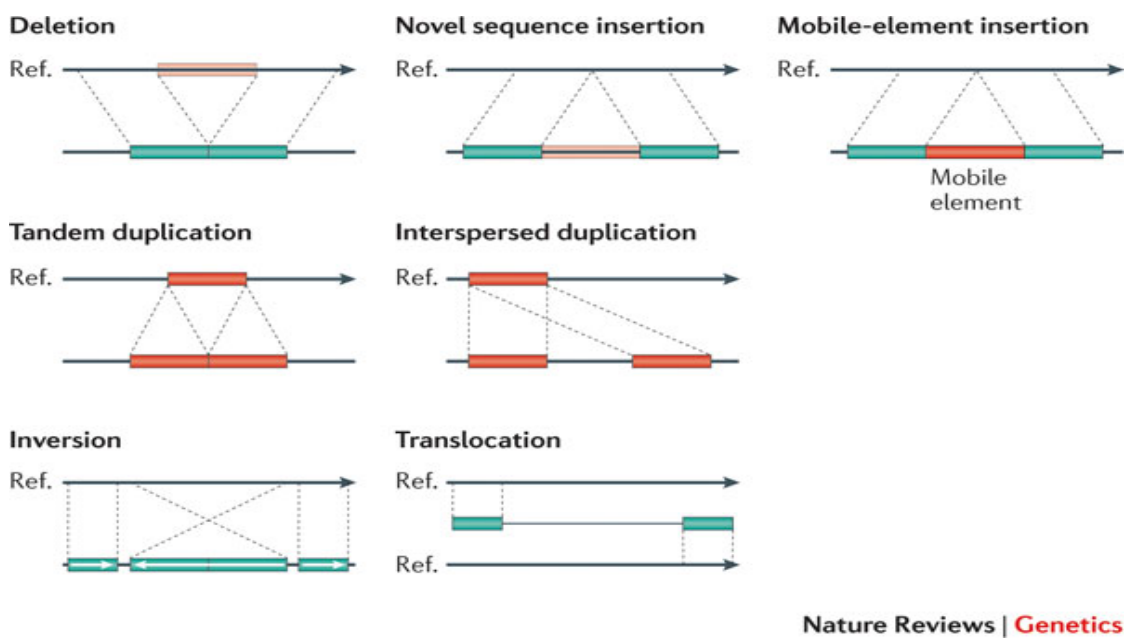
reference: C A C A G T G C G C - T
sample: C A C C G T G - G C A T

SNP *deletion* *insertion*

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

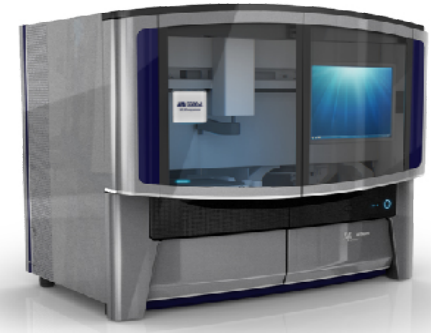
reference: C A G C A G C A G C A G
sample: C A G C A G C A G C A G C A G

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



Genome sequencers

Roche/454



AB SOLiD

Illumina MiSeq

Complete Genomics

Oxford Nanopore MinION

Illumina HiSeq2000

Pacific Biosciences RS

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

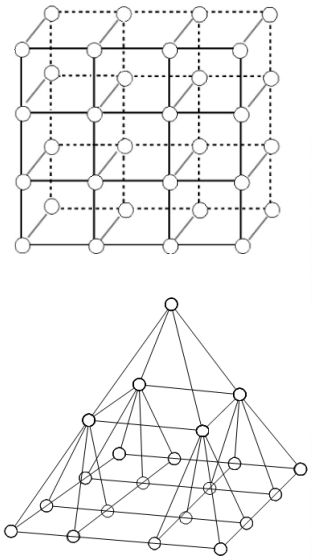
Research Interests

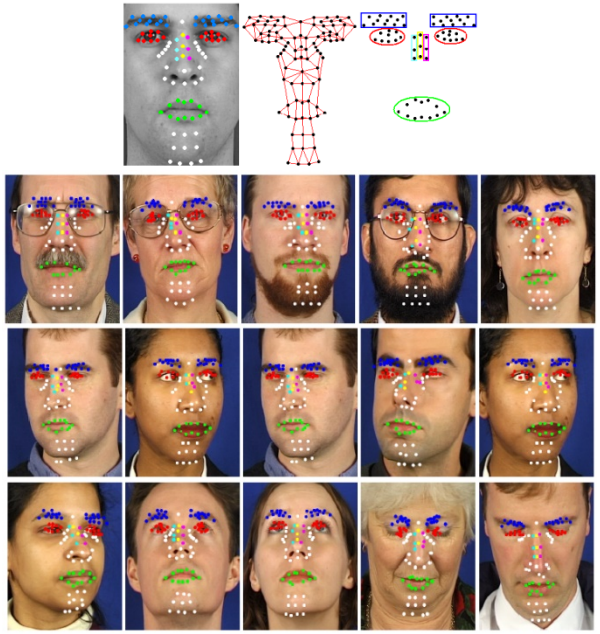
- Computer Vision
- Pattern Recognition
- Machine Learning

Current Research Topics

- Face Recognition
- Face Presentation Attack Detection
- Anomaly Detection

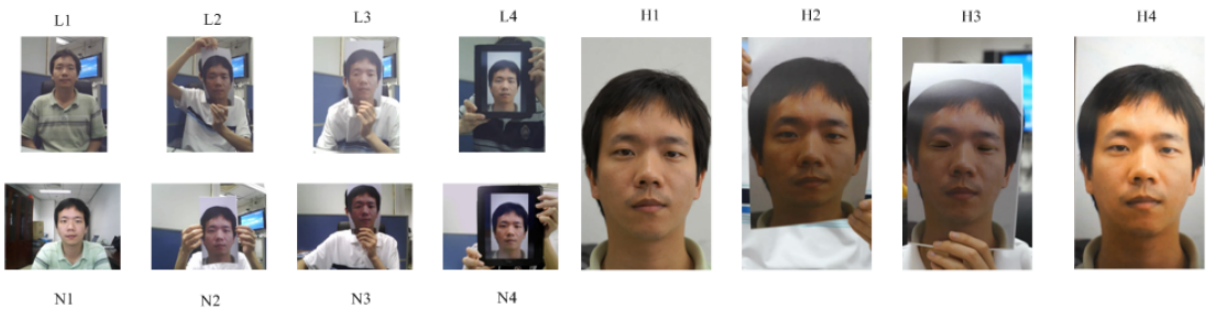
Unconstrained Face Recognition





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

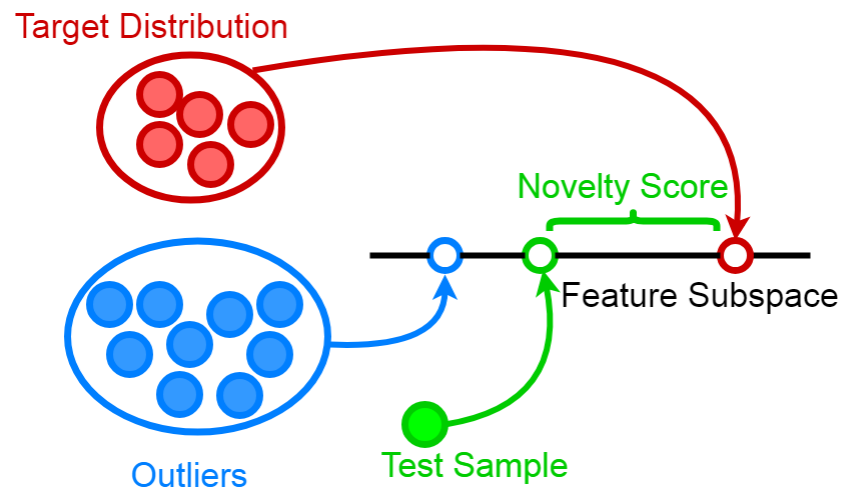
Developing novel methodologies along with applications to:

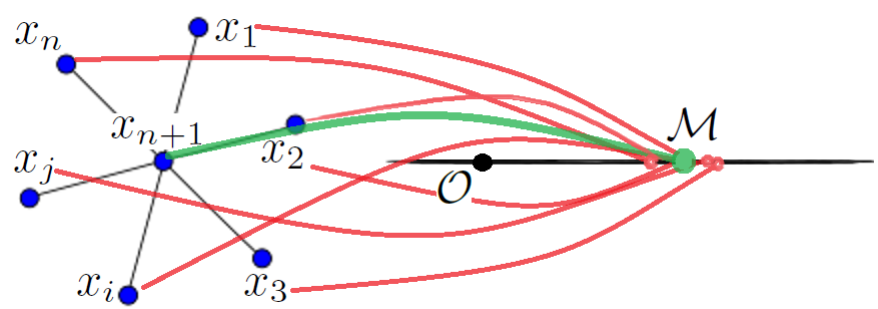
Surveillance

Novelty detection

Healthcare

etc.





Contact Address:
Prof. Cevdet Aykanat
aykanat@cs.bilkent.edu.tr

Bilkent University
High Performance Computing

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 iterative solvers**

Partitioning **irregular domains** for large-scale parallel processing

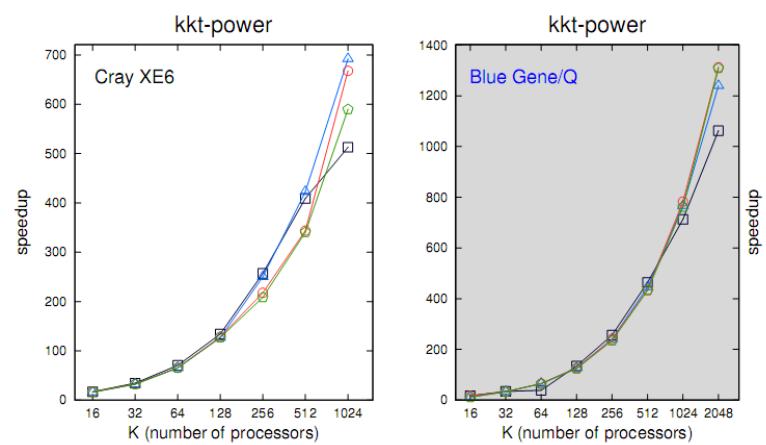
Locality aware scheduling of irregular applications on **Xeon Phi** architecture

Partitioning models for scaling 1D-, 2D- and 3D-parallel **sparse matrix-matrix multiplication** on distributed/shared memory architectures

Partitioning large scale **social networks** and **graph databases**

High performance **parallel graph analytics** kernels for big data applications

- High performance **tensor decomposition** methods for distributed/shared memory parallel systems
- Partitioning models and methods for scaling parallel **stochastic gradient descent** algorithms for **recommendation systems**
- 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

Recent Publications

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, *F. Sukru Torun, Murat Manguoglu, Cevdet Aykanat*, **SIAM Journal on Scientific Computing**, vol. 40, no. 6, pp. 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**, vol 122, no. 145-158, 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.

Exploiting Locality in Sparse Matrix-Matrix Multiplication on Many-Core Architectures, *Kadir Akbudak and Cevdet Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 28, no. 8, pp. 2258–2271, 2017.

A machine learning approach for result caching in web search engines, *Tayfun Kucukyilmaz, B. Barla Cambazoglu, Cevdet Aykanat and Ricardo Baeza-Yates*, **Information Processing & Management**, vol. 53, no. 4, pp. 834–850, 2017.

Parallel Minimum Norm Solution of Sparse Block Diagonal Column Overlapped Underdetermined Systems, *F. Sukru Torun, Murat Manguoglu and Cevdet Aykanat*, **ACM Transactions on Mathematical Software (TOMS)**, vol. 43, no. 4, pp. 31, 2017.

A Recursive Hypergraph Bipartitioning Framework for Reducing Bandwidth and Latency Costs Simultaneously, *Oguz Selvitopi, Seher Acer and Cevdet Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 28, no. 2, pp. 345–358, 2017.

Improving performance of sparse matrix dense matrix multiplication on large-scale parallel systems,*Seher Acer, Oguz Selvitopi and Cevdet Aykanat*, **Parallel Computing**, vol. 59, pp. 71–96, 2016.

Reducing latency cost in 2D sparse matrix partitioning models, *R. Oguz Selvitopi and Cevdet Aykanat*, **Parallel Computing**, vol. 57, pp. 1–24, 2016.

Locality-Aware Parallel Sparse Matrix-Vector and Matrix-Transpose-Vector Multiplication on Many-Core Processors, *M. Ozan Karsavuran, Kadir Akbudak and Cevdet Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 27, no. 6, pp. 1713–1726, 2016.

A Novel Method for Scaling Iterative Solvers: Avoiding Latency Overhead of Parallel Sparse-Matrix Vector Multiplies, *R. Oguz Selvitopi, M. Mustafa Ozdal, Cevdet Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 26, no. 3, pp. 632–645, 2015.

Simultaneous Input and Output Matrix Partitioning for Outer-Product-Parallel Sparse Matrix-Matrix Multiplication, *Kadir Akbudak and Cevdet Aykanat*, **SIAM Journal on Scientific Computing**, vol 36, no. 5, pp. C568–-C590, 2014.

Temporal Workload-Aware Replicated Partitioning for Social Networks, *Ata Turk, R. Oguz Selvitopi, Hakan Ferhatosmanoglu and Cevdet Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 26(5), pp. 1-14, 2014**.**

Improving the Performance of Independent Task Assignment Heuristics MinMin, MaxMin and Sufferage,*E. Kartal Tabak, B. Barla Cambazoglu, Cevdet Aykanat*, **IEEE Transactions on Parallel and Distributed Systems**, vol. 25, no. 5, pp. 1244–1256, 2014.

Constrained Min-Cut Replication for K-Way Hypergraph Partitioning, *E. Kartal Tabak, B. Barla Cambazoglu, Cevdet Aykanat*, **INFORMS Journal on Computing**, vol. 26, no. 2, pp. 303–320, 2014.

A term-based inverted index partitioning model for efficient distributed query processing, *B. Barla Cambazoglu, Enver Kayaaslan, Simon Jonassen, Cevdet Aykanat*, **ACM Transactions on the Web (TWEB)**, vol. 7, no. 3, 2014.

Contact Address:
Prof. Cevdet Aykanat
aykanat@cs.bilkent.edu.tr

Recent Funded Projects

TUBITAK/COST Projects

119E035: Parallel Stochastic Gradient Descent Algorithms for Large-Scale Recommendation Systems, 1/7/2019 - 31/12/2021

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 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 (Task leader)

PRACE 1IP-Extension 01/07/2013 - 01/07/2014

D7.1.3 Application Enabling for Capability Science in the MIC Architecture

PRACE 1IP 01/07/2010 - 01/07/2013

D7.5 HPC Programming Techniques (Task leader)

Contact Address:
Prof. Cevdet Aykanat
aykanat@cs.bilkent.edu.tr

Current Positions of Some Former PhD. Students

- Dr. Seher Acer, 2017. **Sandia National Lab**., Postdoc
- Dr. Oguz Selvitopi, 2017. **Lawrence Berkeley National Lab**., Postdoc
- Dr. Şükrü Torun, 2017. **Yıldırım Beyazıt University**, Assistant Professor
- Dr. Kadir Akbudak, 2015. **KAUST**, Postdoc
- 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**, Postdoc
- 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
Sepehr Bakhshi
Alican Büyükçakır
Sevil Çalışkan
Sanem Elbaşı
Pouya Ghahramanian
Ömer Gözüaçık
Aykut Güven

UG Student(s)
Taha Aksu

Some Prev. Members
Cem Aksoy
Ahmet Buğdaycı
Hayrettin Erdem
Cem Karbeyaz
Süleyman Kardaş
Cihan Kaynak
H. Çağdaş Öcalan
Anıl Türel
İbrahim Uysal

Other Contributors
Hamed R. Bonab, UMass
Dilek Küçük, TÜBİTAK
Çağrı Toraman, UCF

Research Interests

Information Retrieval (IR)

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

- 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

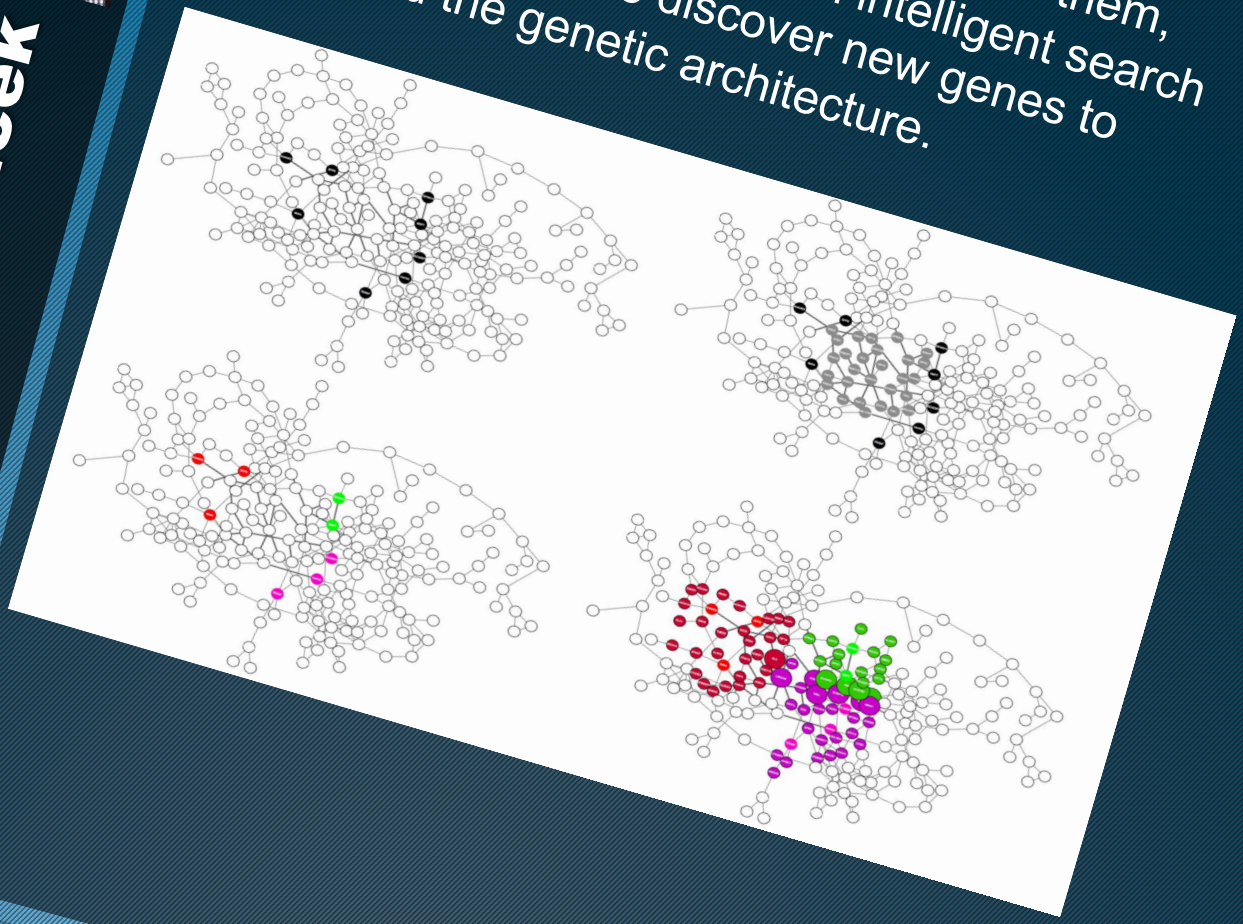
cicek@cs.bilkent.edu.tr

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

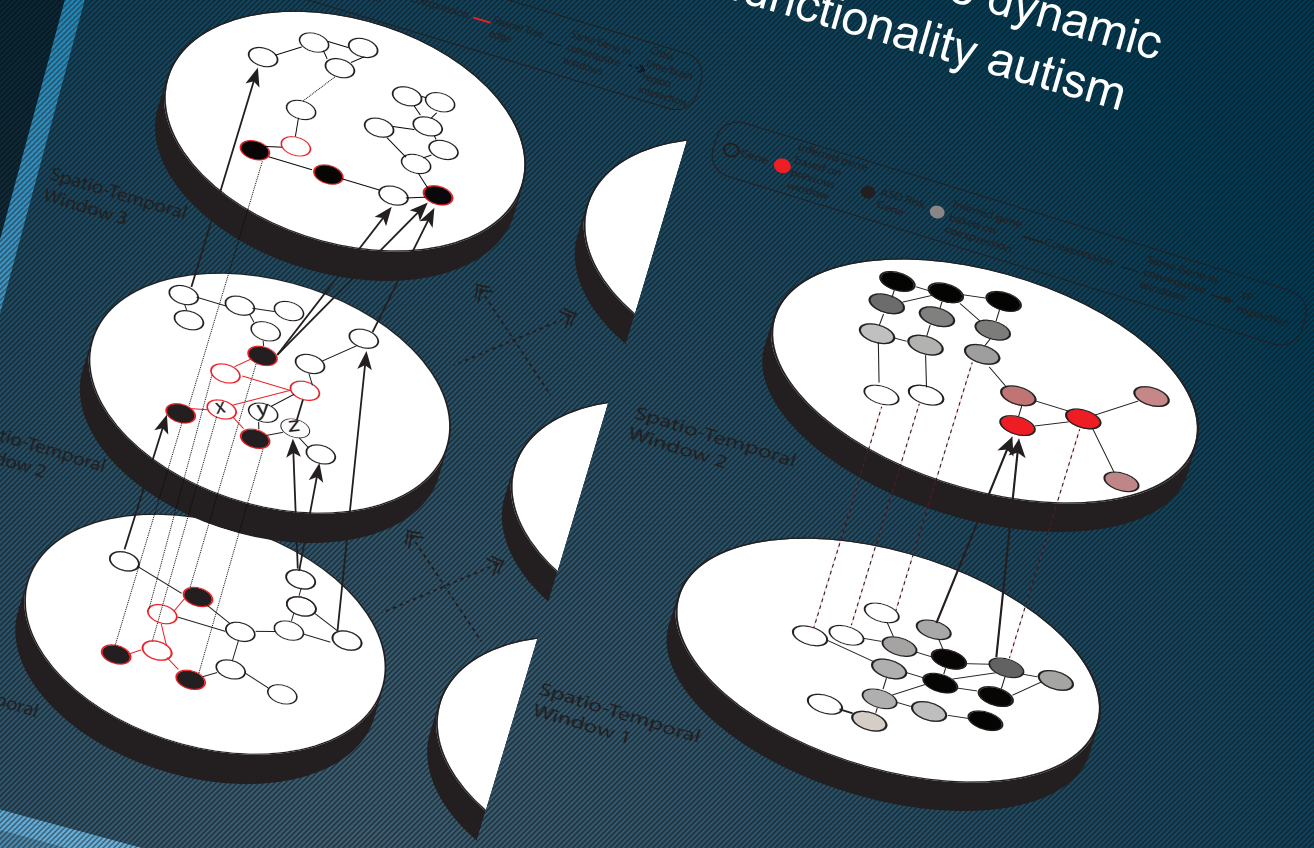
cicek@cs.bilkent.edu.tr

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

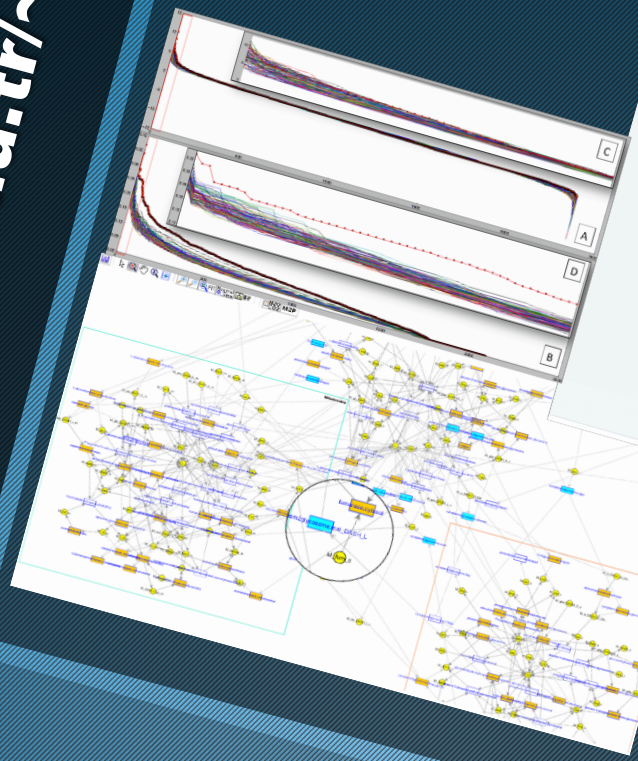
cicek@cs.bilkent.edu.tr

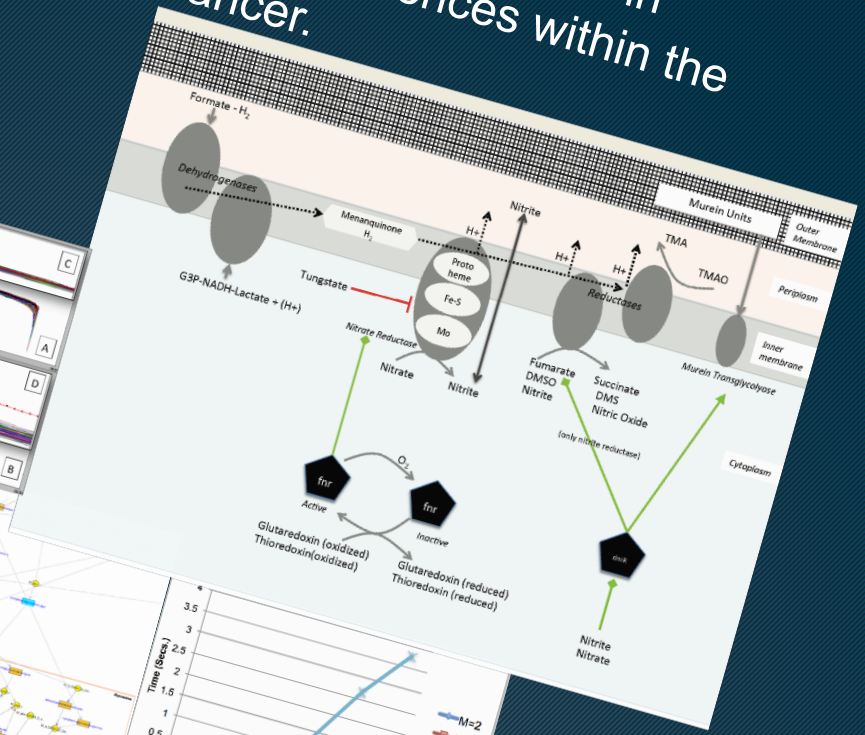
cs.bilkent.edu.tr/~cicek

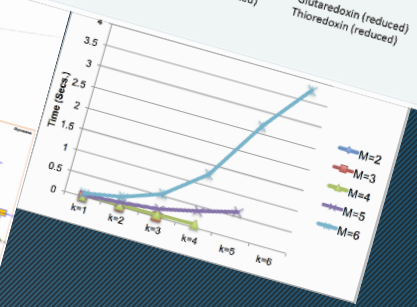
Metabolic Networks to Understand Cancer

Metabolites are the small compounds in the body and have been found to be key biomarkers to define certain tumors.

We use network algorithms and build online systems that analyze metabolic signatures in tumors and understand the differences within the subtypes of the same cancer.







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** 9(1) : e1002859

Tuğrul Dayar

(tugrul@cs.bilkent.edu.tr)

- **Performance modeling and analysis**
- **Scientific computing (especially numerical linear algebra for stochastic matrices)**
- **Bioinformatics**
- **Computer networks**

requires solid background:

1) in computer engineering

2) specifically in probability theory, linear algebra, numerical analysis, and high-level programming,

which one must either have or be willing to develop

Visit:

www.cs.bilkent.edu.tr/~tugrul/tugrul.html

for further information

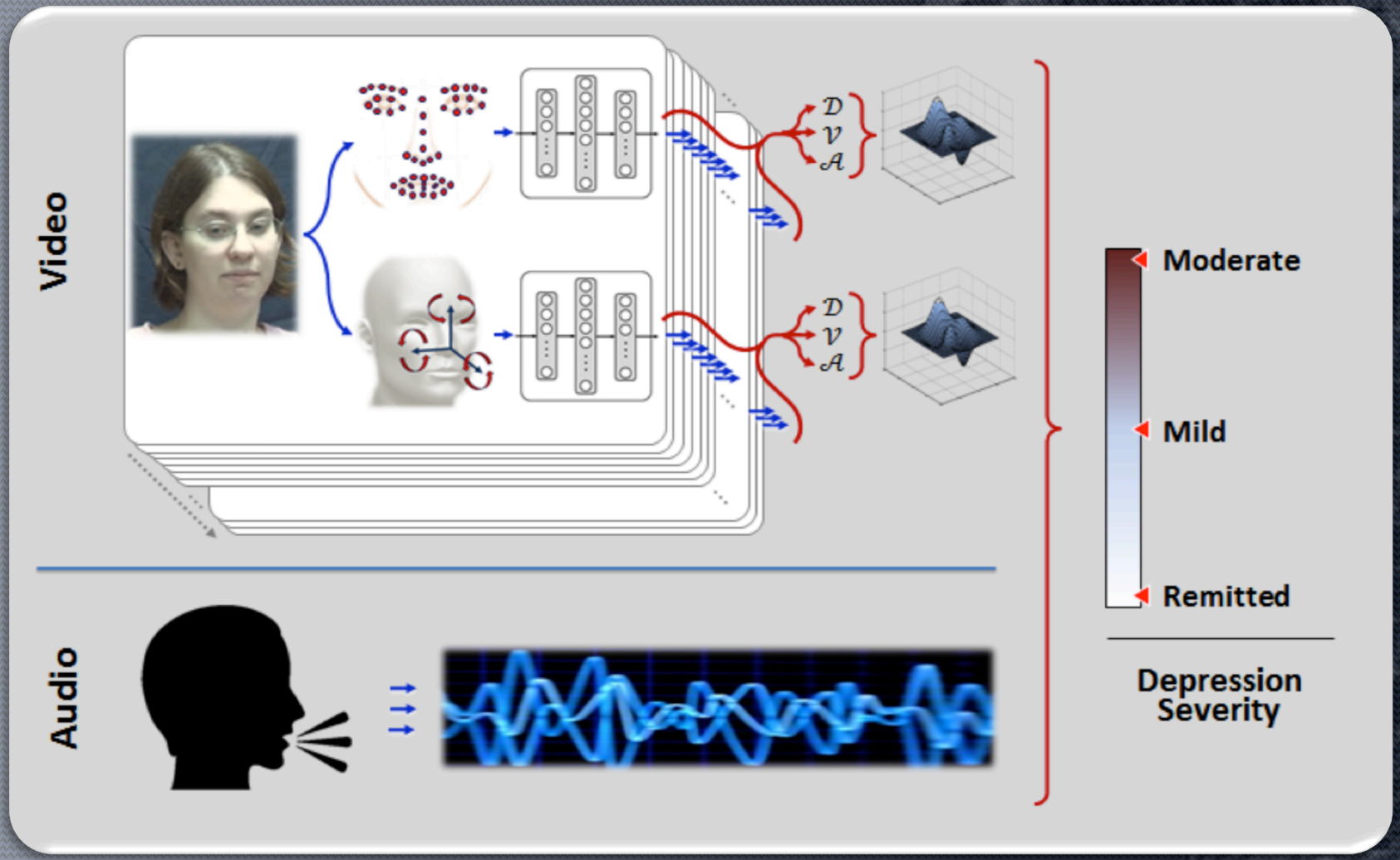
Hamdi Dibeklioğlu

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.

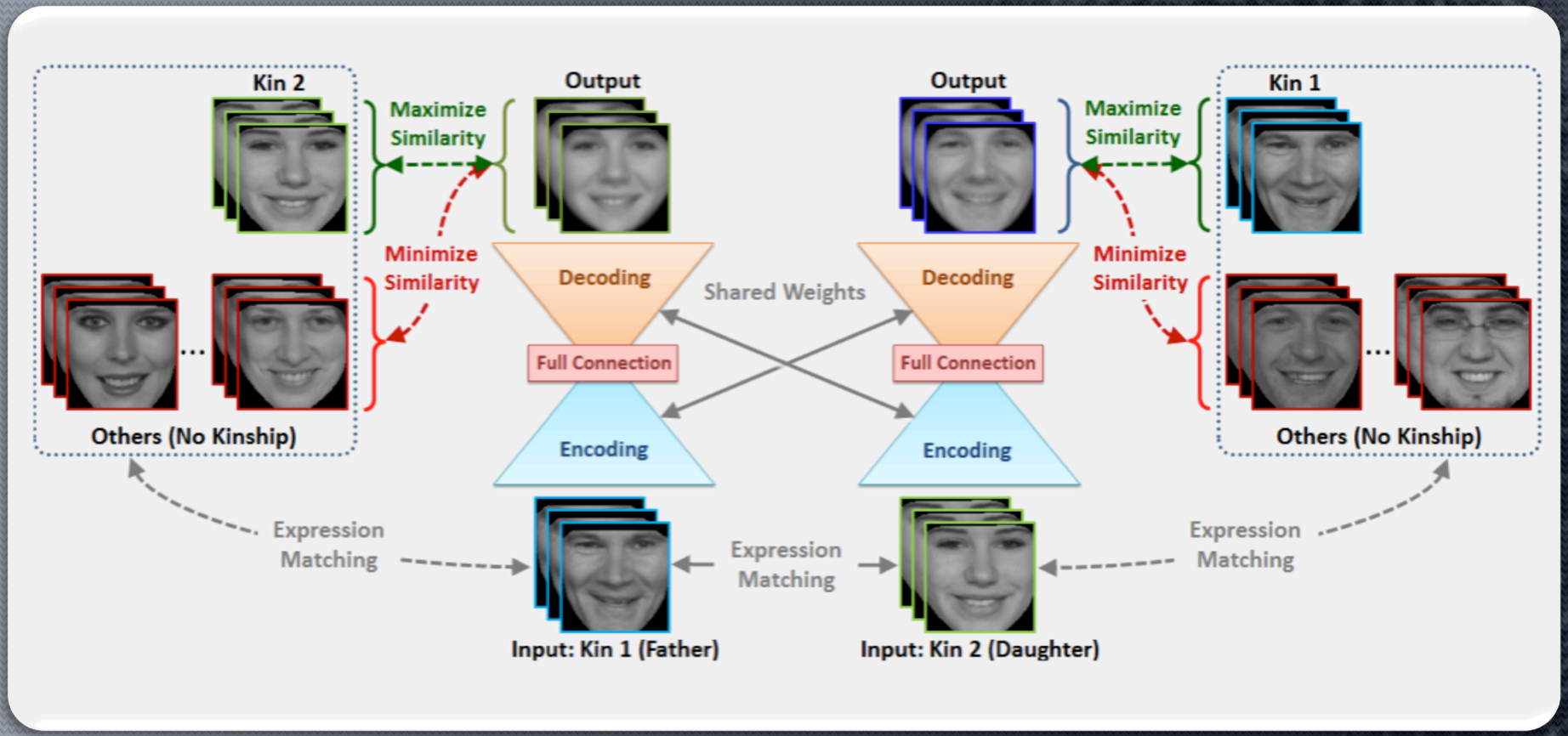
My current research mainly focuses on multimodal analysis of non-verbal human behavior (e.g. face analysis, gesture recognition, etc.) and deep learning of temporal representations.

Assessment of Depression Severity



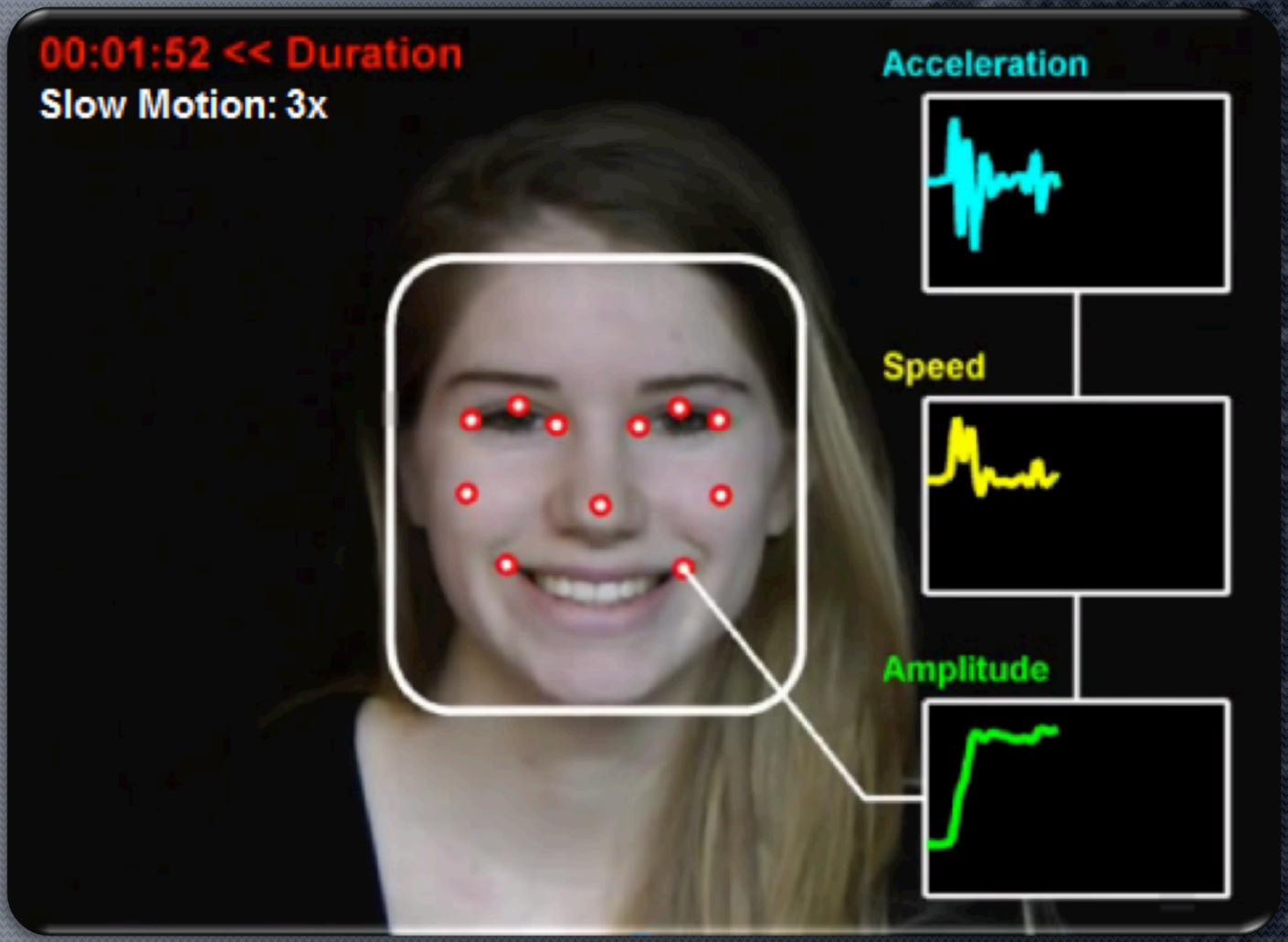
dibeklioglu@cs.bilkent.edu.tr | http://www.cs.bilkent.edu.tr/~dibeklioglu/

Kinship Verification



dibeklioglu@cs.bilkent.edu.tr | http://www.cs.bilkent.edu.tr/~dibeklioglu/

Age Estimation through Facial Dynamics



dibeklioglu@cs.bilkent.edu.tr | http://www.cs.bilkent.edu.tr/~dibeklioglu/

Facial Expression Recognition

dibeklioglu@cs.bilkent.edu.tr | http://www.cs.bilkent.edu.tr/~dibeklioglu/

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.

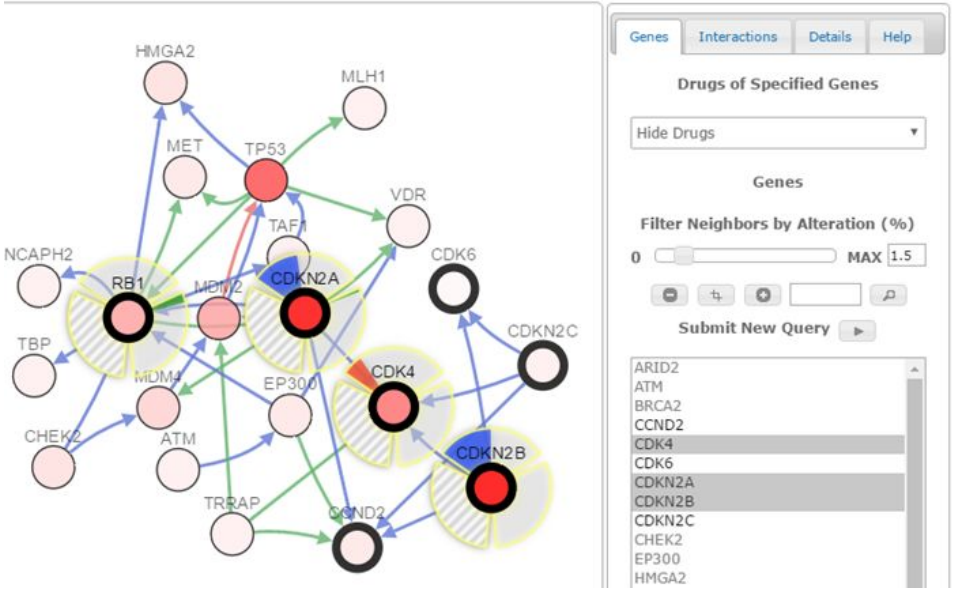
Big data visualization & analytics, Pathway visualization & informatics, Graph drawing & layout, Graph database querying algorithms

Ugur Dogrusoz

Click here for live/animated version

Example Applications

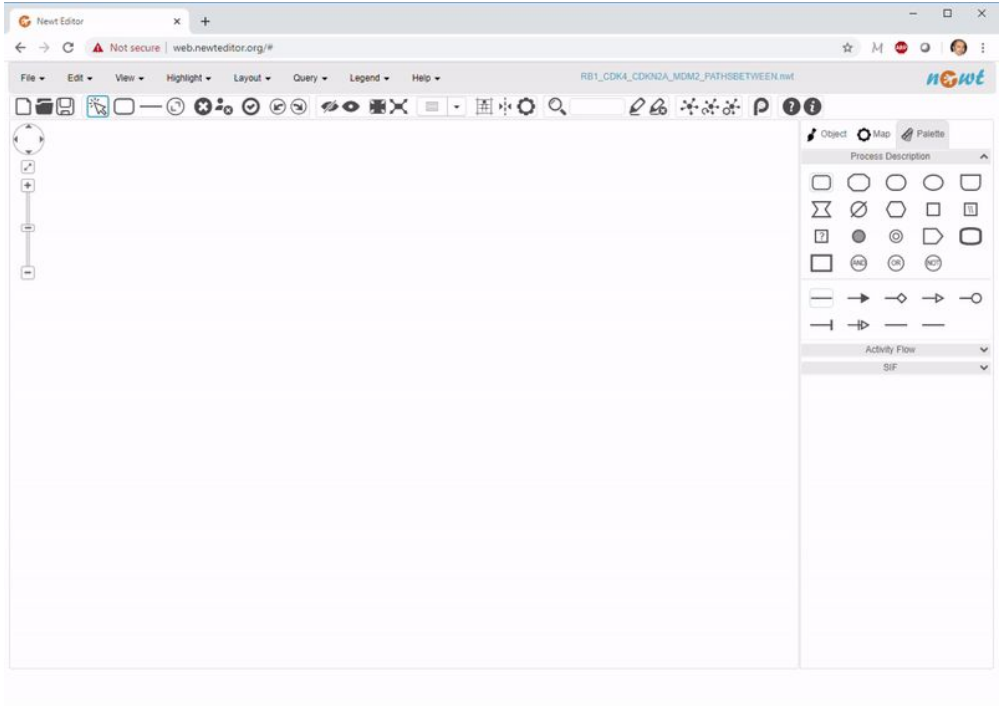
- Understanding human metabolism and disease conditions through **biological pathway** analysis
- Identifying fraud in **financial networks**
- Management and monitoring of computer networks
- Understanding how people behave and collaborate online to improve web sites through **social network** analysis
- Detecting and monitoring of terrorist or criminal networks via **telecommunication network** analysis



Cerami, Gao, Dogrusoz et al., The cBio Cancer Genomics Portal: An open source platform for exploring multi-dimensional cancer genomics data, Cancer Discovery, 2012

Graph Queries

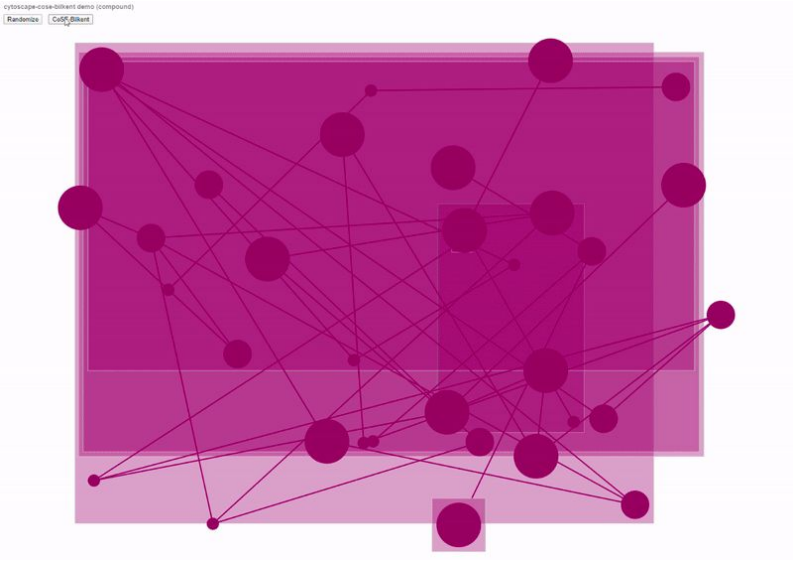
- Access database to get a “graph/network of interest” from “nodes of interest”
- Graph algorithms
  - Shortest paths
  - Neighborhoods
  - Common targets / sources
  - Centrality
  - Often requires variations (e.g. shortest + k length paths)



Dogrusoz et al., Algorithms for Effective Querying of Compound Graph-Based Pathway Databases, BMC Bioinformatics, 2009

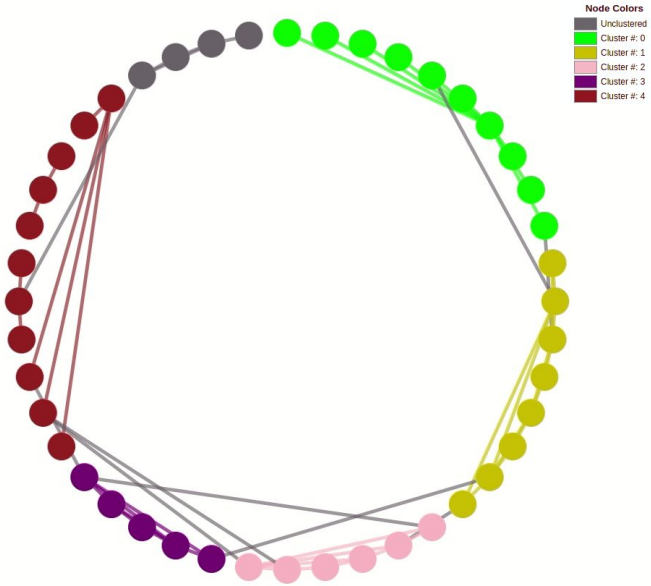
Automatic Graph Layout

Automatic layout of compound / nested graphs



Dogrusoz et al., "A Layout Algorithm For Undirected Compound Graphs", Information Sciences, 179, pp. 980-994, 2009.

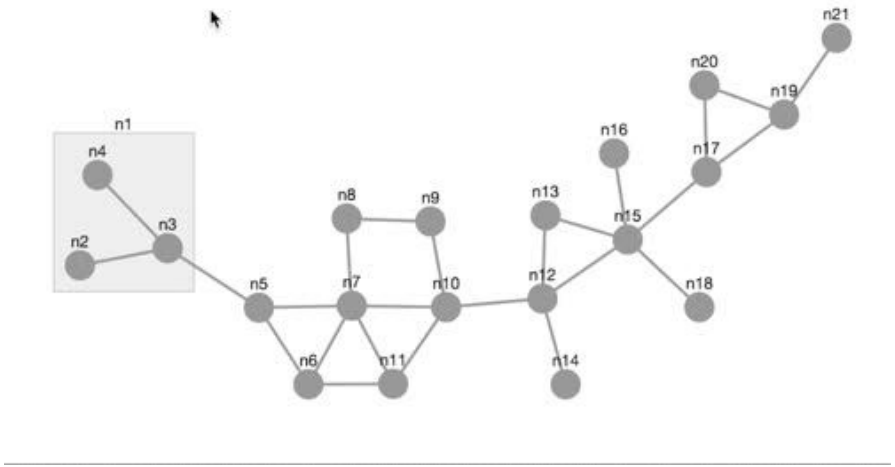
Automatic layout of clustered / grouped graphs



Dogrusoz et al., "CiSE: A Circular Spring Embedder Layout Algorithm", IEEE Transactions on Visualization and Computer Graphics, 19(6), pp. 953-66, 2013.

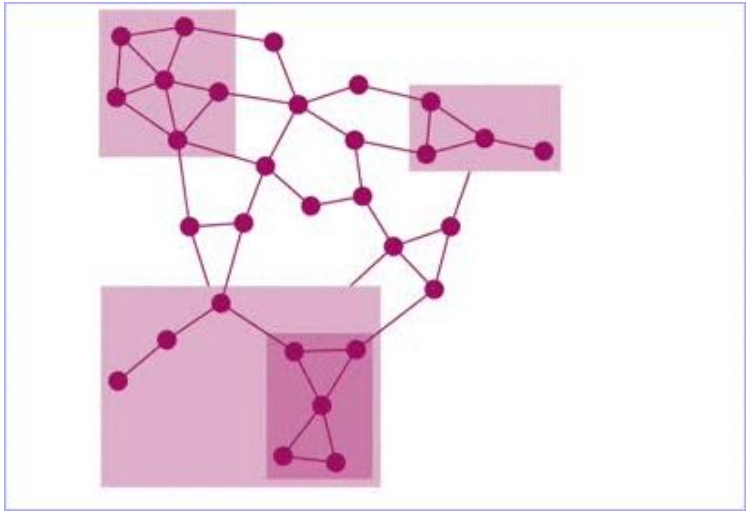
Complexity Management

Hide-show: hide currently non-interesting parts and reveal on demand



Dogrusoz et al., "Efficient methods and readily customizable libraries for managing complexity of large networks", PLOS ONE, 13(5): e0197238, 2018.

Expand-collapse: collapse groups / clusters to later expand on deman



Dogrusoz et al., "A Multi-Graph Approach to Complexity Management in Interactive Graph Visualization", Computers & Graphics, 30(1), pp. 86-97, 2006.

Evolving Networks

Time based filtering and animation

Collaborators

OREGON HEALTH & SCIENCE UNIVERSITY

Memorial Sloan Kettering Cancer Center

BADER LAB

UNIVERSITY OF TORONTO

DANA-FARBER CANCER INSTITUTE

HARVARD MEDICAL SCHOOL

eisbm European Institute for Systems Biology & Medicine

Tom Sawyer SOFTWARE

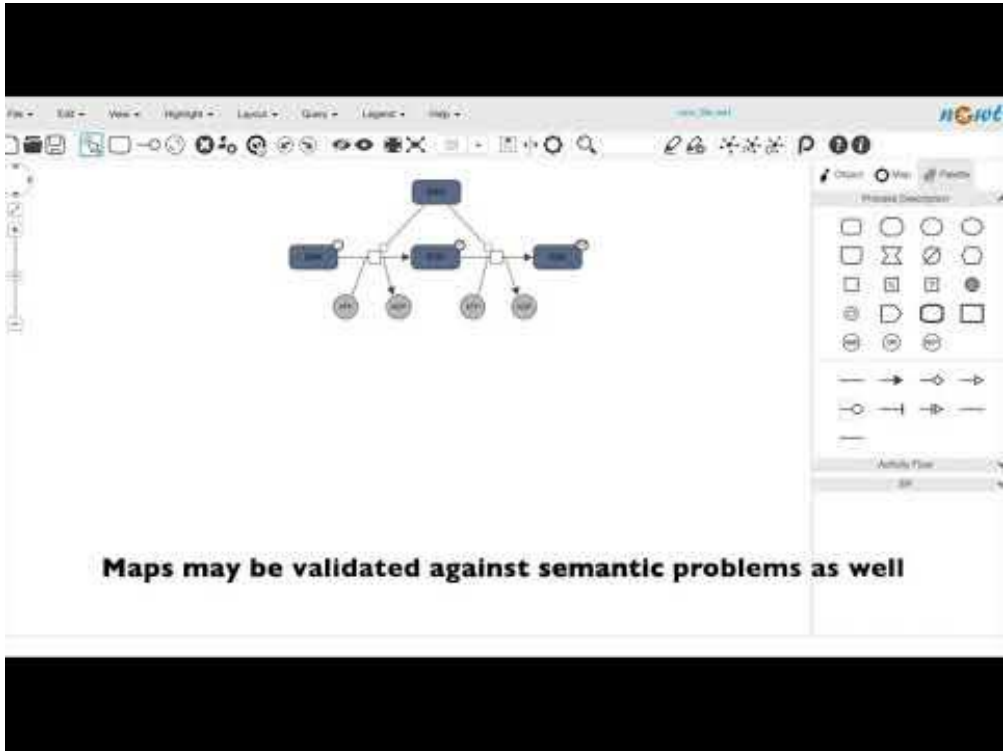
Certain company

Certain company

Software Highlights

newteditor.org

Pathways simplified: View, design, and analyze pathways in SBGN...



Sari, Bahceci, Dogrusoz et al., "SBGNViz: a tool for visualization and complexity management of SBGN process description maps", PLOS ONE, 10(6), e0128985, 2015.

Software Highlights

PathwayMapper

pathwaymapper.org & cbioportal.org

Collaborative pathway curation tool for interactive creation, editing, and sharing of cancer pathways

Bahceci, Dogrusoz, La et al., "PathwayMapper: a collaborative visual web editor for cancer pathways and genomic data", Bioinformatics, 33(14), pp. 2238-40, 2017.

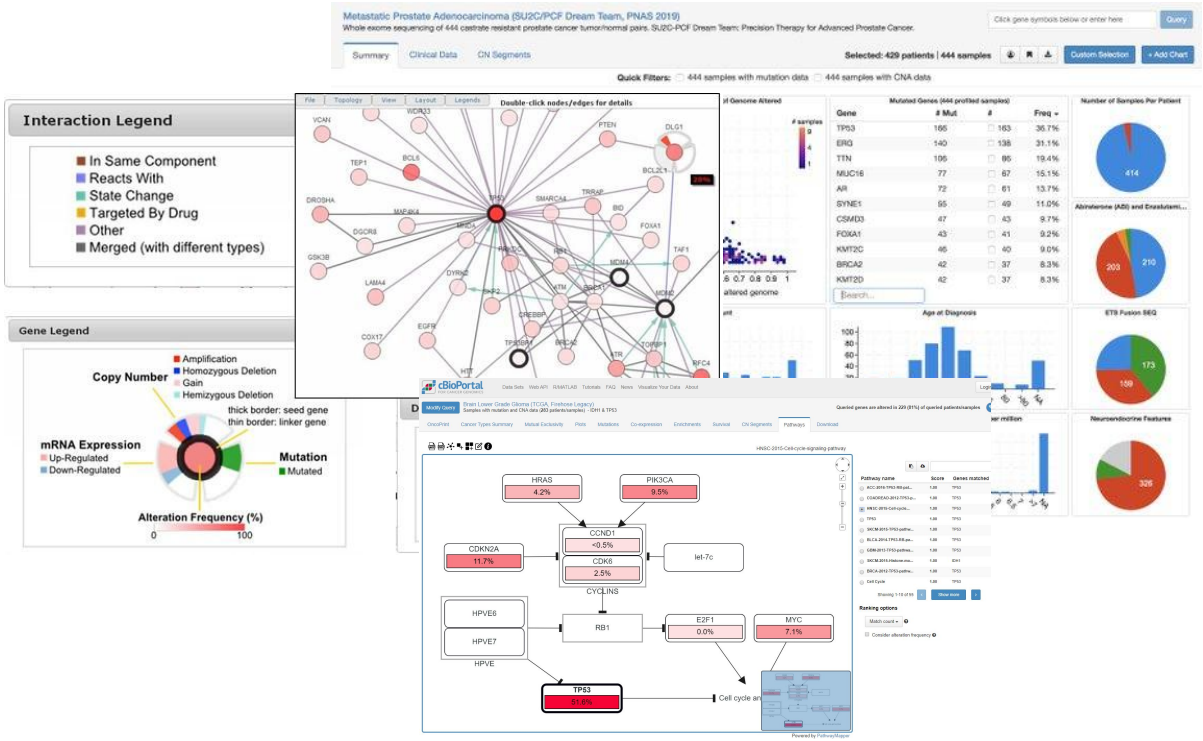
Sanchez-Vega et al., "Oncogenic Signaling Pathways in The Cancer Genome Atlas", Cell, 173(2), pp. 321-337.e10, 2018.

Software Highlights

cbioportal

cbioportal.org

Visualization, analysis, and download of large-scale cancer genomics data sets



Gao, Aksoy, Dogrusoz et al., "Integrative analysis of complex cancer genomics and clinical profiles using the cBioPortal", Science Signaling, 6(269), pl1, 2013.

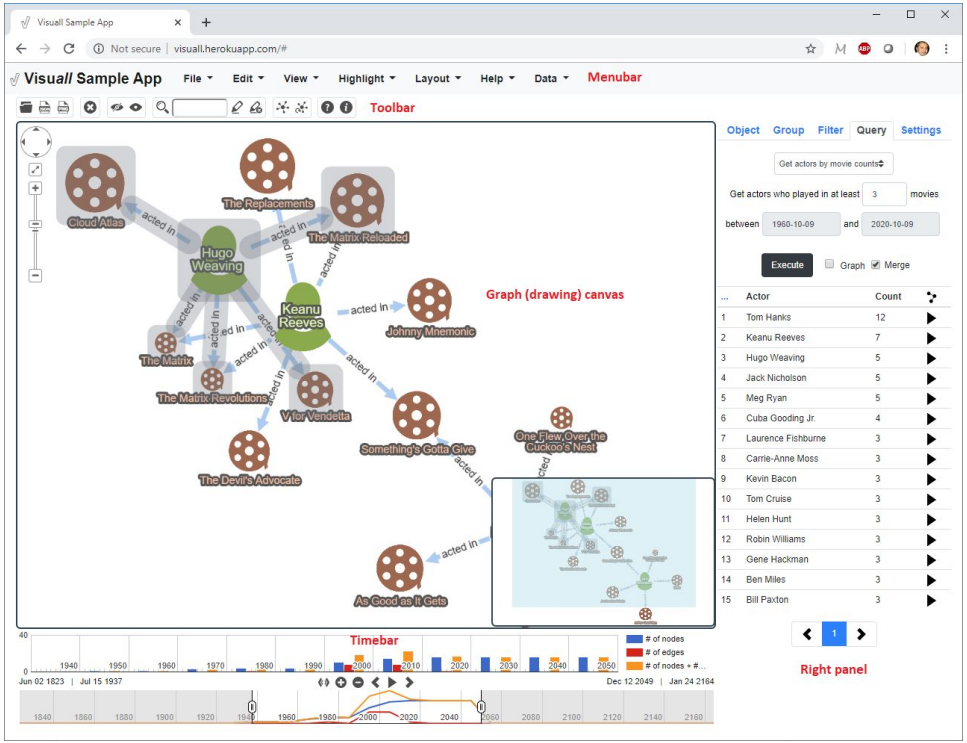
Sanchez-Vega et al., "Oncogenic Signaling Pathways in The Cancer Genome Atlas", Cell, 173(2), pp. 321-337.e10, 2018.

Software Highlights

Visu*all*

A proprietary software library used by companies for commercial purposes

A library to jump start software developers in building a visual web based component for analysis of relational information

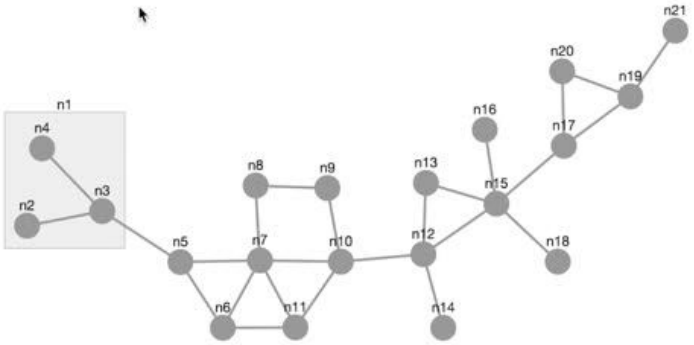


Software Highlights: complexity management

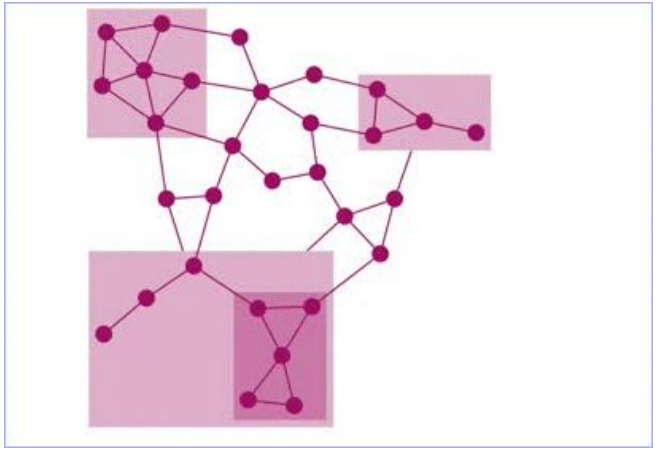
https://js.cytoscape.org/#extensions

Generic plugins for Cytoscape.js used by many to build commercial and non-commercial visualization software

27★ cytoscape.js-view-utilities: hide/show, highlight, zoom



52★ cytoscape.js-expand-collapse: manage complexity with expand-collapse

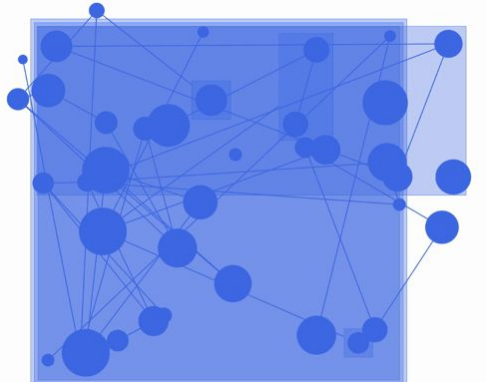


Software Highlights: automatic layout

https://js.cytoscape.org/#extensions

Generic plugins for Cytoscape.js used by many to build commercial and non-commercial visualization software

67★ cytoscape.js-cose-bilkent: compound graph layout

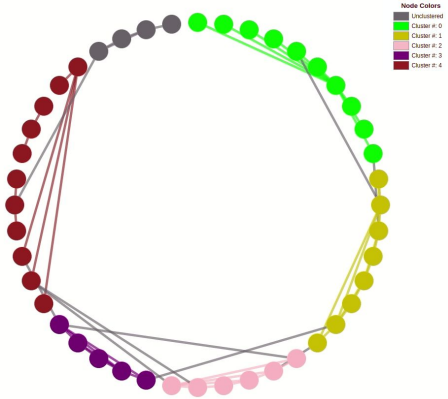


11★ cytoscape.js-fcose: fast compound graph layout

3★ cytoscape.js-layout-utilities: placement of new nodes and polyomino packing of components

3★ cytoscape.js-avsdf: circular layout

3★ cytoscape.js-cise: clustered graph layout

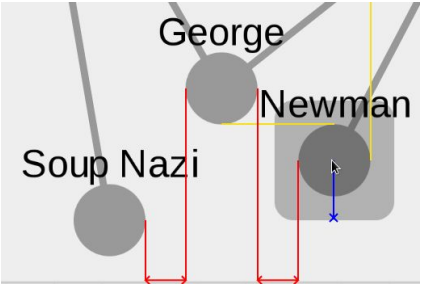


Software Highlights: graph editing

https://js.cytoscape.org/#extensions

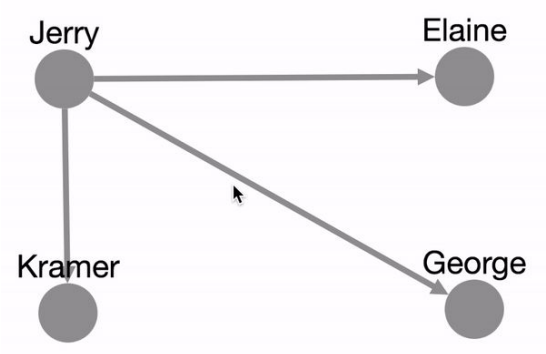
Generic plugins for Cytoscape.js used by many to build commercial and non-commercial visualization software

24★ cytoscape.js-grid-guide: grid and guidelines for convenient placement of nodes

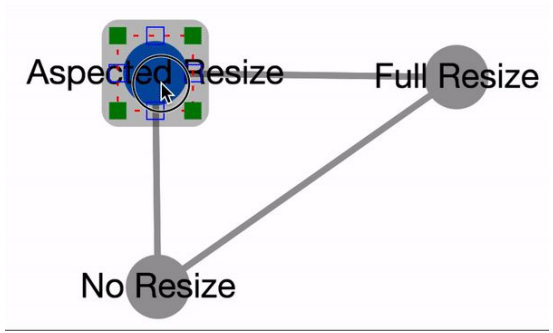


25★ cytoscape.js-undo-redo: undo/redo of graph editing operations

8★ cytoscape.js-edge-editing: reconnection and rerouting of edges



11★ cytoscape.js-node-resize: interactive resizing of nodes

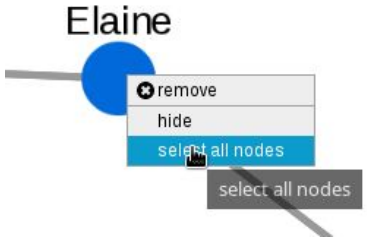


Software Highlights: miscellaneous

https://js.cytoscape.org/#extensions

Generic plugins for Cytoscape.js used by many to build commercial and non-commercial visualization software

38★ cytoscape.js-context-menus:
context-sensitive menus on graph objects



19★ cytoscape.js-graphml:
bi-directional conversion between graphml and Cytoscape.js

7★ cytoscape.js-autopan-on-drag:
automatic panning on drag out of drawing canvas

Contact

ivisatbilkent@gmail.com

http://www.cs.bilkent.edu.tr/~ivis

https://twitter.com/ivisatbilkent

https://github.com/iVis-at-Bilkent

iVis Info. Visualization Research Lab.

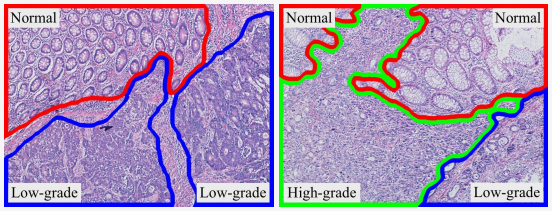
Click here for live/animated version

Çiğdem Gündüz Demir

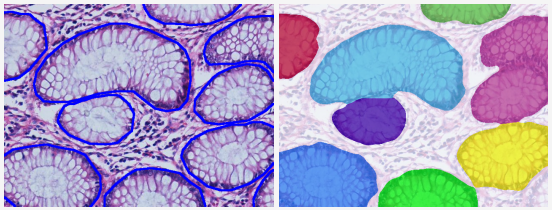
http://www.cs.bilkent.edu.tr/~gunduz

gunduz@cs.bilkent.edu.tr

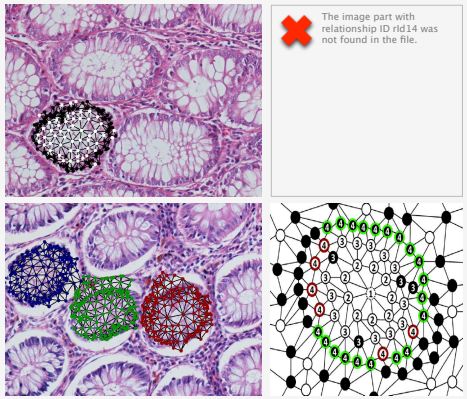
Digital pathology: classification and segmentation in biopsy images



End-to-end segmentation in biopsy images

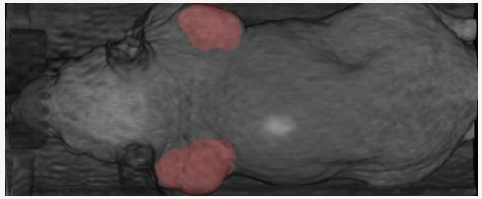


Gland/cell segmentation in colon tissues

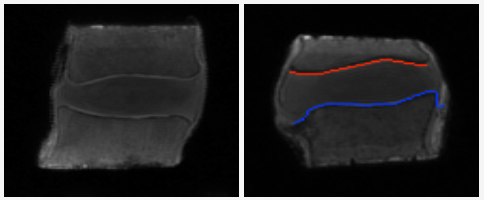


High-level representation of histopathological images and colon cancer classification

CT and MR image analysis for in vivo images

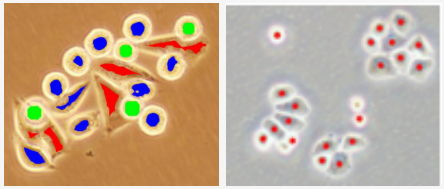


Subcutaneous tumor segmentation



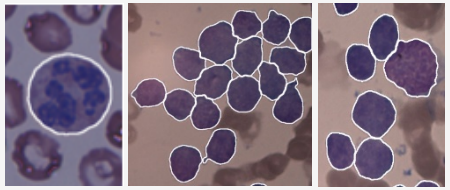
Cartilage endplate segmentation

High content screening: cell segmentation in microscopic images



Cell segmentation in phase contrast microscopy

Cell segmentation in fluorescence microscopy

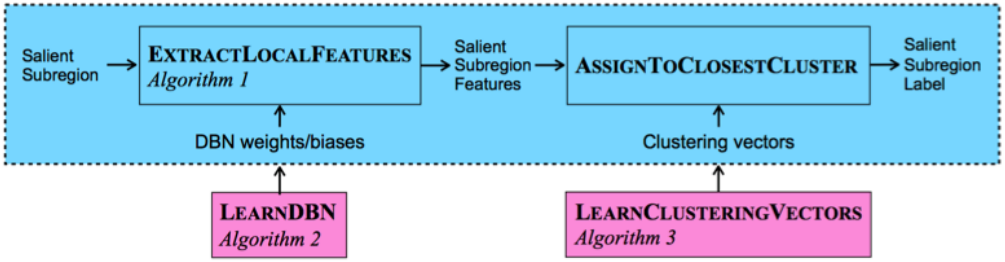


Cell segmentation in peripheral blood and bone marrow images

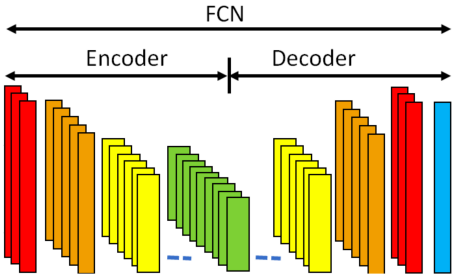
Deep Learning for Medical Image Analysis

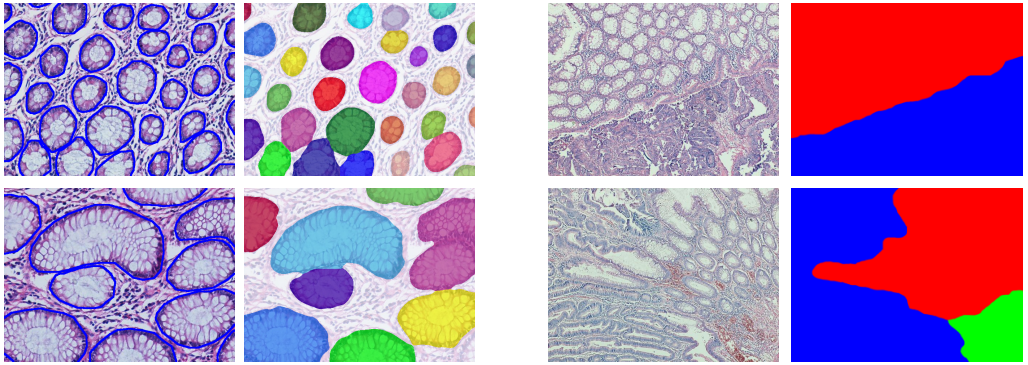
Digital Pathology

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



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

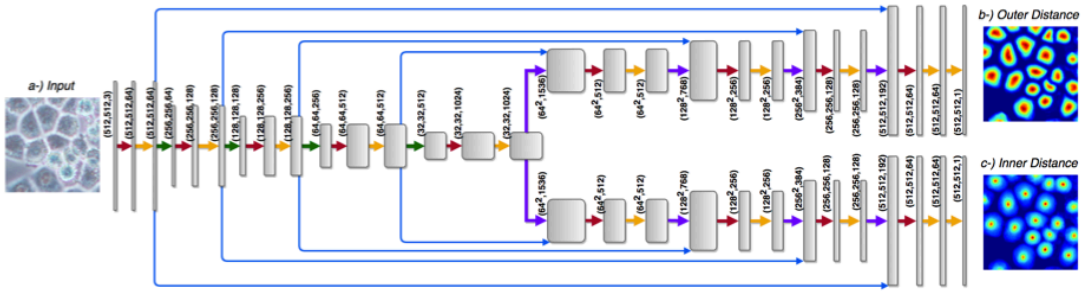


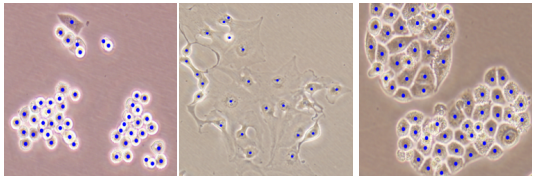


Deep Learning for Medical Image Analysis

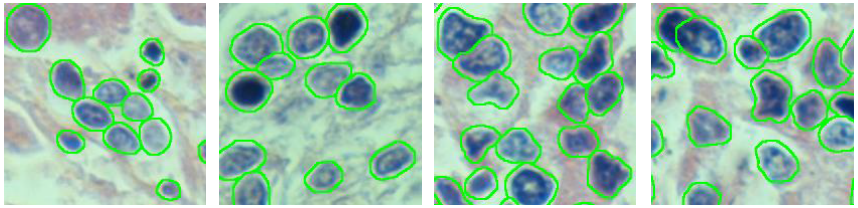
Cell Segmentation

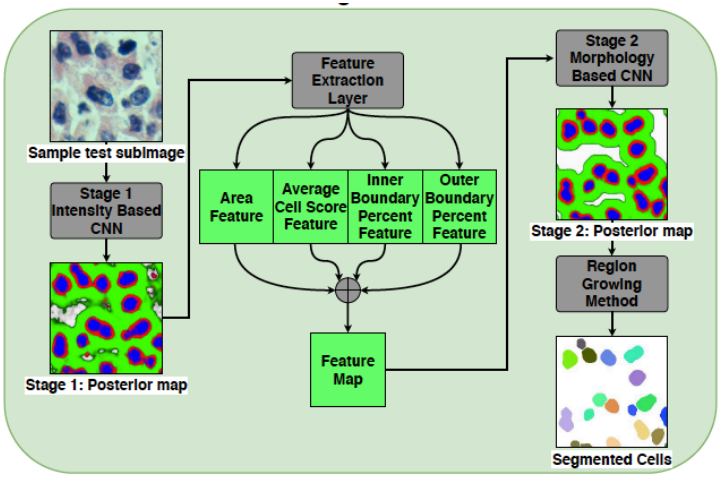
Multi-task models for cell detection in live cell microscopy





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





Computer Graphics

Uğur Güdükbay

http://www.cs.bilkent.edu.tr/~gudukbay

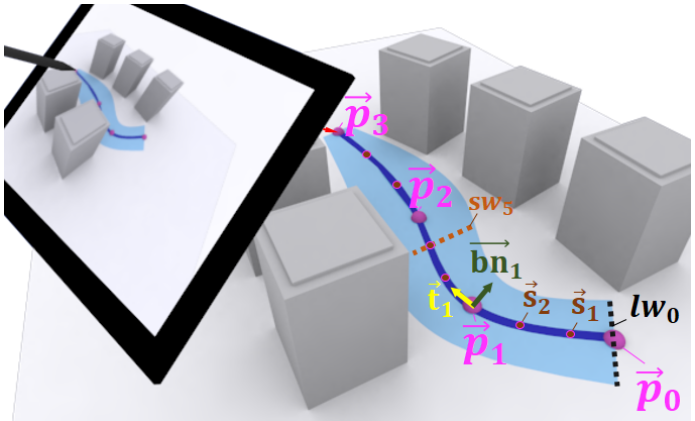
gudukbay@cs.bilkent.edu.tr

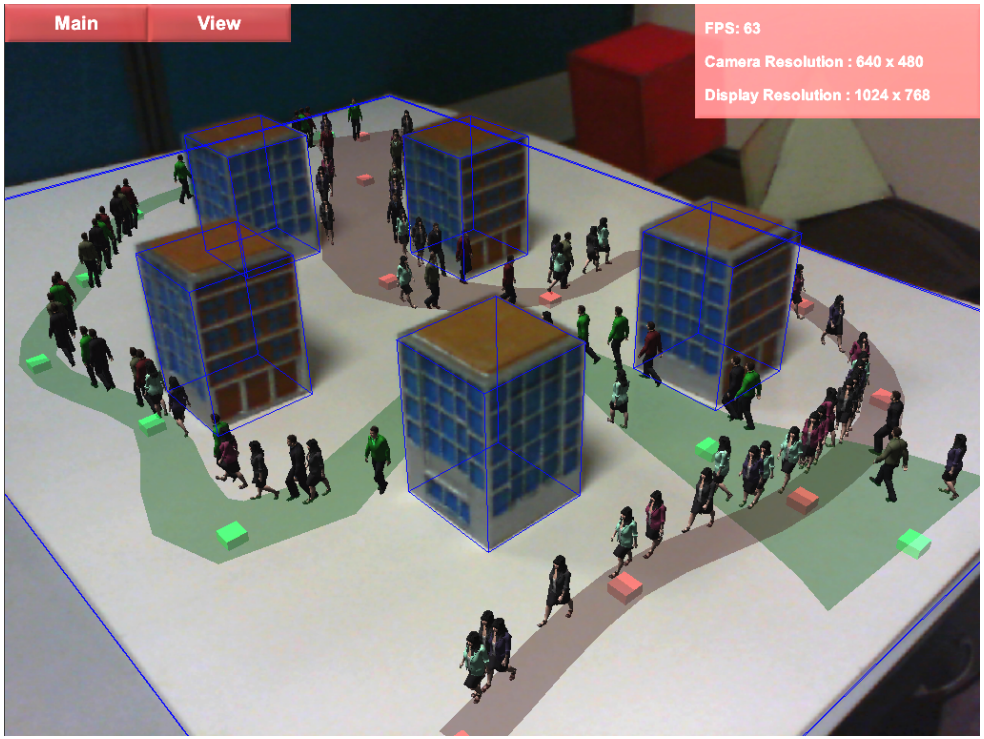
Research Topics:

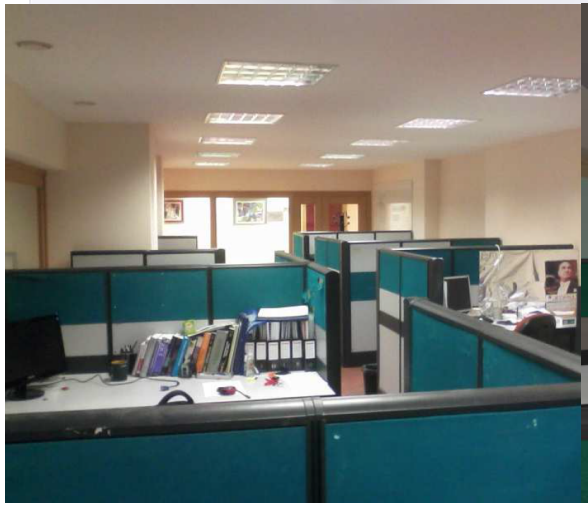
1. Augmented and Virtual Reality
2. Terrain and Urban Modeling and Visualization
3. Human Modeling and Animation

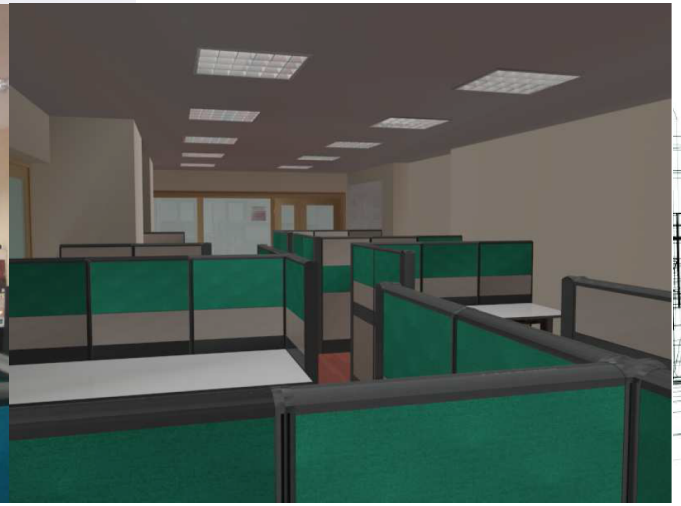
Augmented and Virtual Reality

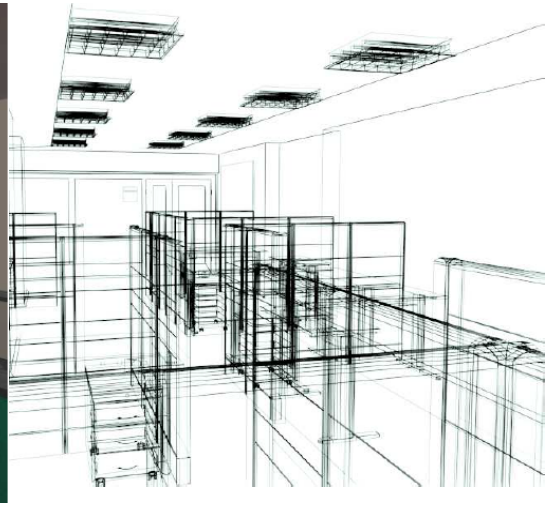
- Crowd Simulation
- Realistic Lighting
- Camera Registration and Tracking
- Augmented Reality on Mobile Devices



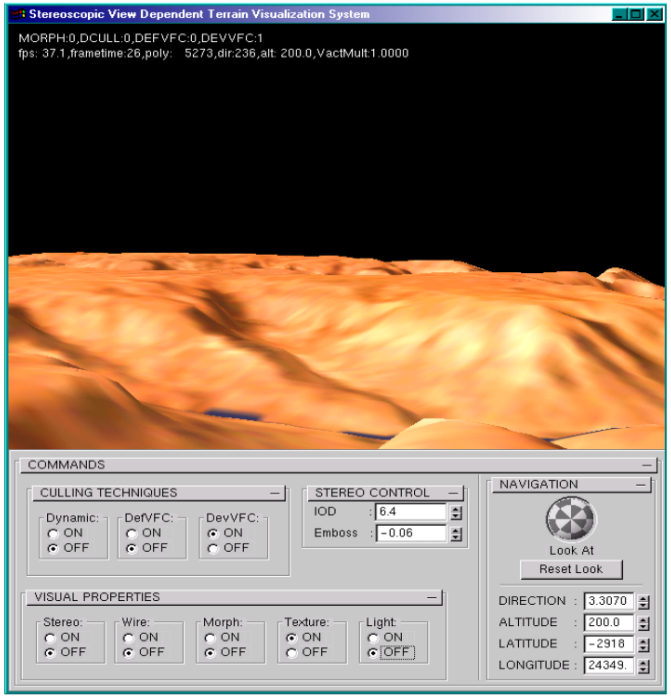




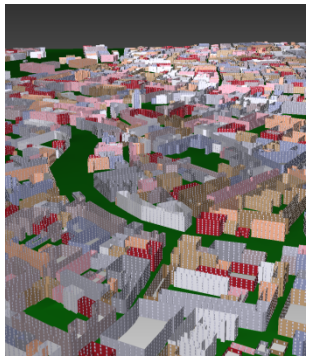


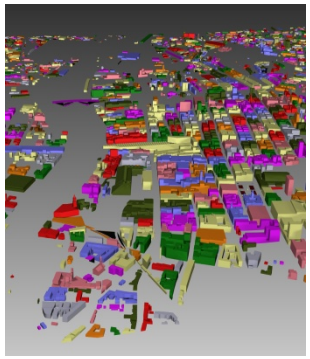


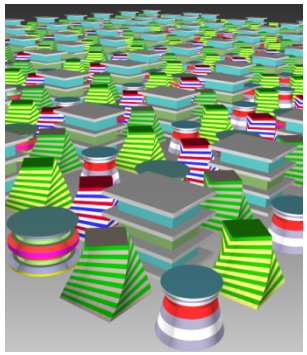
Terrain and Urban Modeling and Visualization

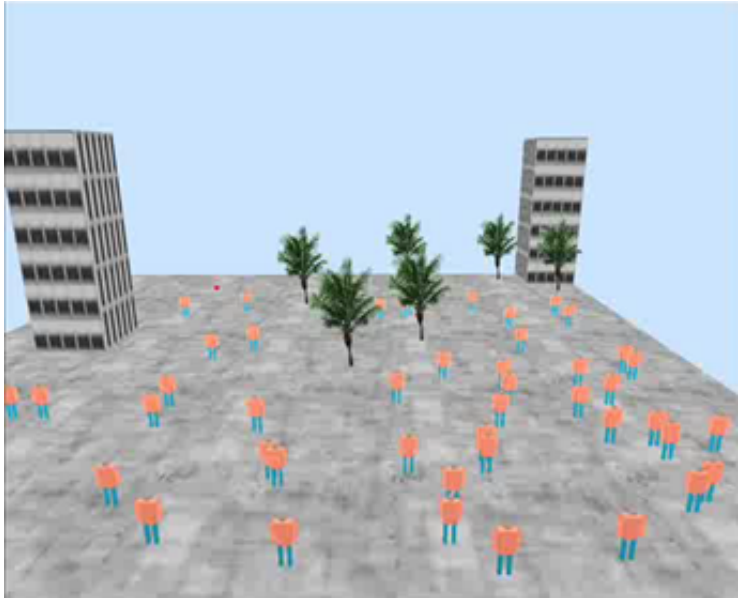


- **Level-of-detail management**
- **View-dependent refinement**
- **Stereoscopic visualization**
- **GPU-based tessellation**
- **Crowd simulation in urban environments**

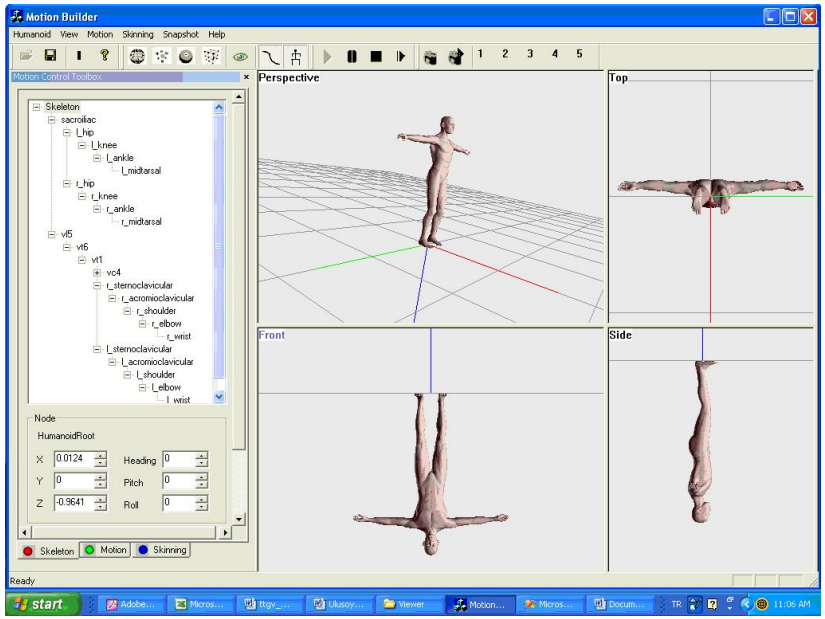








Human Modeling and Animation



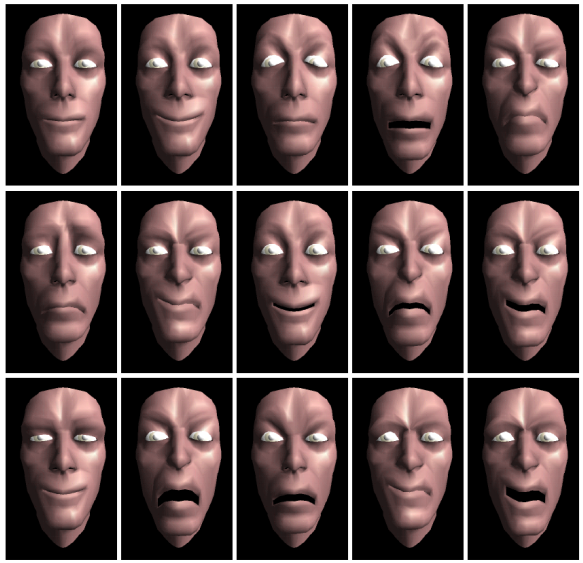


Figure 2: Different facial expressions and expression combinations; from left-to-right and top-to-bottom (rowwise order): neutral, happiness, surprise, fear, anger, sadness, disgust, happy_surprise, anger_surprise, disgust_surprise, happy_anger, anger_fear, anger_sadness_surprise, anger_sadness_disgust, anger_sadness_surprise_disgust

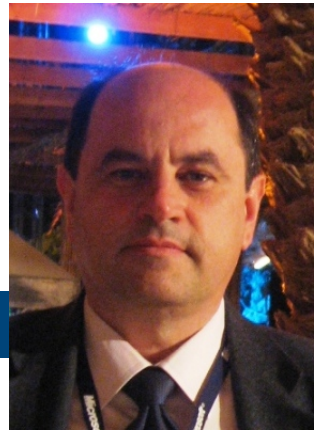
Real-time Virtual Garment Fitting Using Depth Sensor Data

Realistic Rendering of Joint Regions Using Bone Splitting

A Model Wearing a Sundress with Different Postures

A Model Wearing a Vest and Jeans with Different Postures

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

Bilkent University – Department of Computer Engineering

Faculty Member

Ibrahim Korpeoglu

Assoc. Professor
Dept of Computer Engineering
Bilkent University

Email: korpe@cs.bilkent.edu.tr
Web: http://www.cs.bilkent.edu.tr
Office: Engineering EA 409
Phone: 290 25 99

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

- Research Areas:
  - Computer **Networks**
  - Computer **Systems**
  - Network and Distributed **Algorithms**
  - **Wireless** Networks
  - **Distributed** Systems
  - **Cloud** Computing
  - **P2P** Networks
  - **Sensor** Networks
  - **Internet** of Things
  - **WiFi** and Bluetooth
  - Big **Data Systems**

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

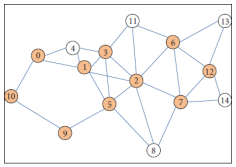
- FIRESENSE Fire Detection and Management through a **Multi-Sensor Network** for the Protection Cultural Heritage Areas from the Ri of Fire and Extreme Weather Conditions
  Sponsor: European Commission FP7 Programme, ENV

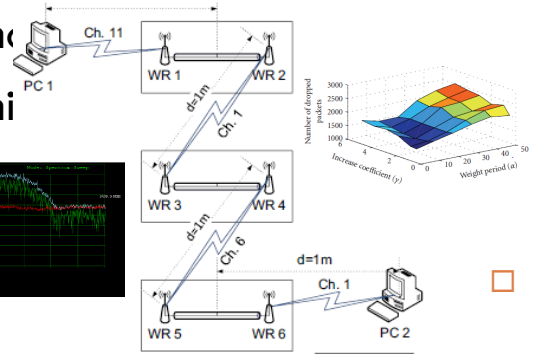
- Network of Excellence in **Wireless Communications** (NEWCOM and NEWCOM++)
  Sponsor: European Commission FP7 Programme, ICT

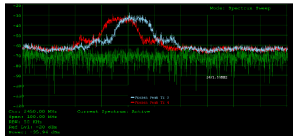
Networks and Systems Research Group

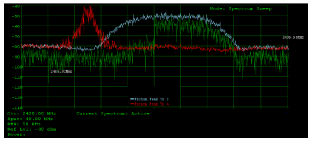
Sample Current Work

- **Wireless Mesh Networks**
  - Routing
  - Channel assignment
  - Interference m
  - Interference mi

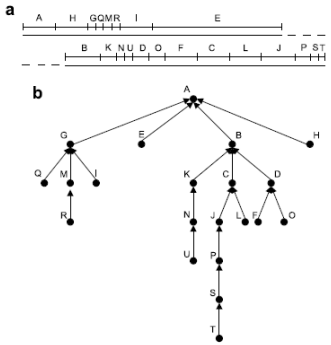




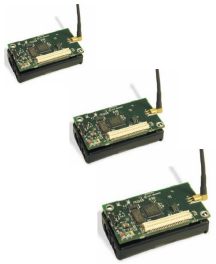


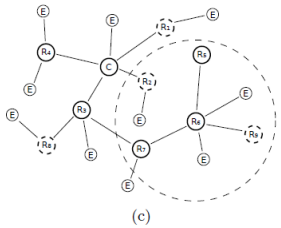


- **Testbeds**
- **Cloud Computing**
  - Resource allocation
  - VM placement
  - Network virtualization
  - Network embedding



- **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
- **Delay tolerant networks**
  - Routing and Scheduling

Networks and Systems Research Group

Sample Publications

- 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*, 2014.
- 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*, 2014.
- Metin Tekkalmaz, **Ibrahim Korpeoglu**. **PSAR: Power-Source-Aware Routing in ZigBee Networks**, *ACM Wireless Networks Journal*, 2012.
- Huseyin Ozgur Tan, **Ibrahim Korpeoglu**, Ivan Stojmenovic, **Computing Localized Power Efficient Data Aggregation Trees for Sensor Networks**, *IEEE Transactions on Parallel and Distributed Systems*, 2011.
- Eyuphan Bulut, **Ibrahim Korpeoglu**, **Sleep Scheduling with Expected Common Coverage in Wireless Sensor Networks**, *ACM Wireless Networks Journal*, 2011.
- Metin Tekkalmaz, Hasan Sozer, **Ibrahim Korpeoglu**, **Distributed Construction and Maintenance of Bandwidth and Energy Efficient Bluetooth Scatternets**, *IEEE Transactions on Parallel and Distributed Systems*, 2006.

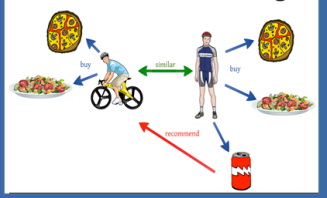
Mustafa Ozdal

www.cs.bilkent.edu.tr/~mustafa.ozdal

High-Performance and Energy Efficient Computing

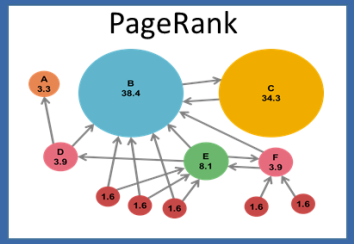
Algorithms, Systems, and Applications

Collaborative Filtering

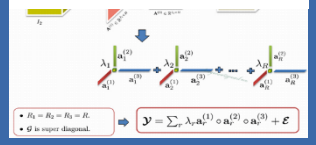


Graph Analytics

PageRank



Scientific Computing

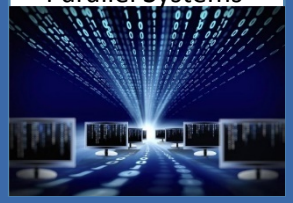


FPGAs

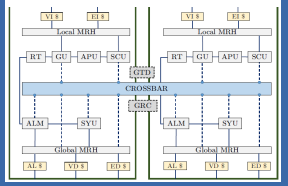
GPUs

Xeon Phi

Parallel Systems



Novel Architectures



Mustafa Ozdal

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:

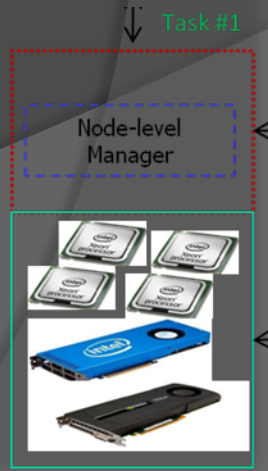
- Strong algorithmic background and analytical skills
- Interest in solving programming puzzles
- C++ programming skills
- Experience with multi-core, GPU, and/or FPGA programming

For more information, see www.bilkent.edu.tr/~mustafa.ozdal. You can send an email to mustafa.ozdal@cs.bilkent.edu.tr to set up an appointment.

Özcan Öztürk

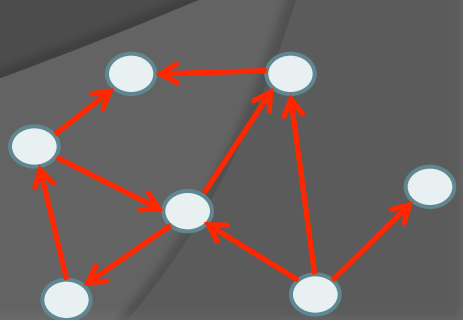
Office: EA 421 Phone: 290-3444
Email: ozturk@cs.bilkent.edu.tr
URL: http://www.cs.bilkent.edu.tr/~ozturk

- **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
http://www.cs.bilkent.edu.tr/~eraytuzun
Office: EA-524

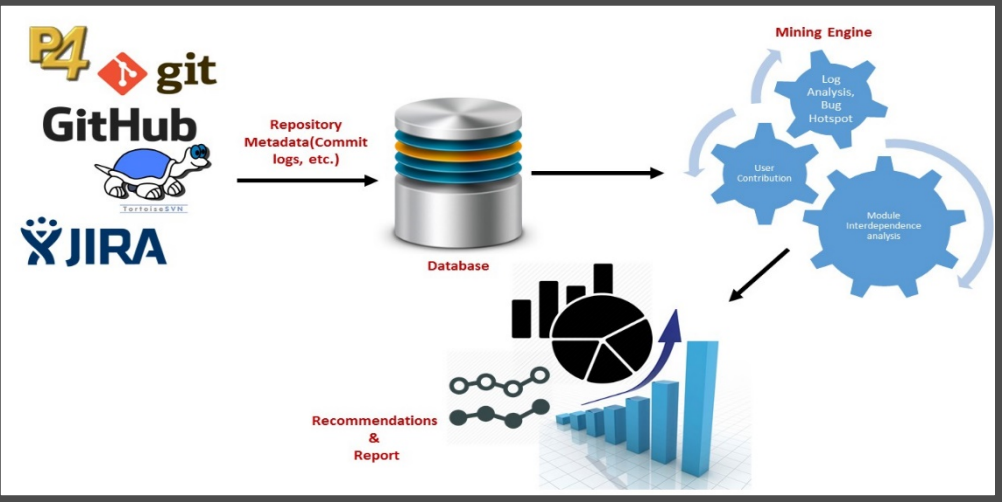
Research Areas

- Software Analytics
- Software Product Line Engineering
- Gamification / Serious Games
- Software Engineering Education
- Software Development Processes
- Empirical Software Engineering

Interested in being part of our research group? Please contact us at eraytuzun@cs.bilkent.edu.tr

Bilkent University Software Engineering and Data Analytics Research Group (BILSEN)
https://bilsengroup.github.io

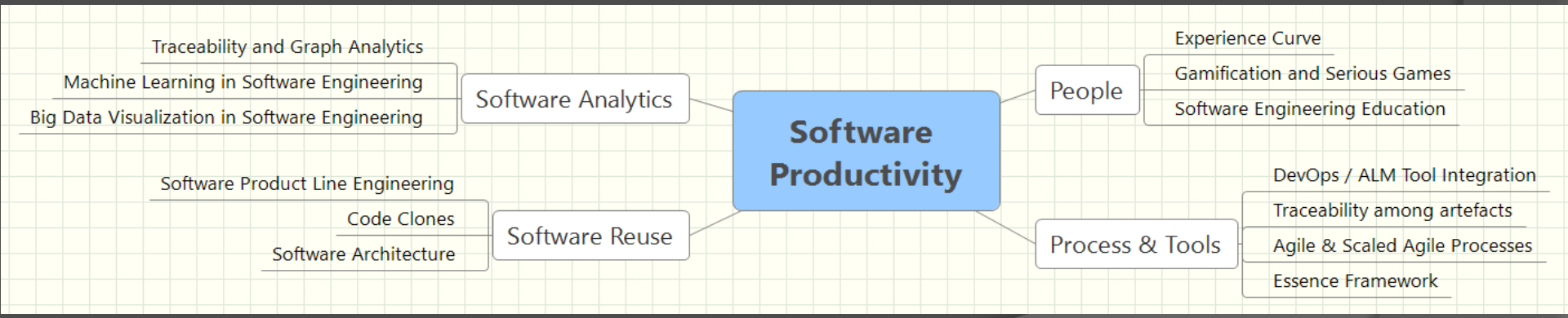
Software Analytics & Software Productivity



"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"

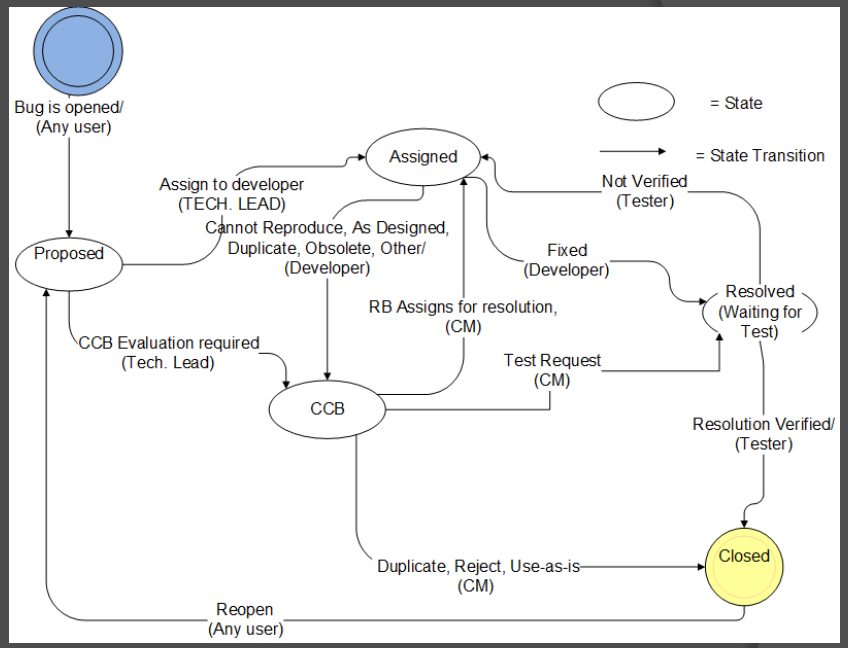
Ahmed E. Hassan and Tao Xie

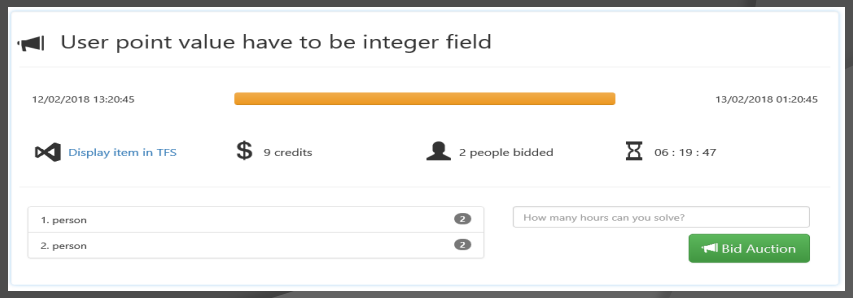
Programmers who changed this function also changed
Don't program on Fridays
Which files are more likely to be buggy?



Serious Games & Gamification in Software Engineering

- **Gamification** is the use of game mechanics to drive engagement in non-game business scenarios and to change behaviors in a target audience to achieve business outcomes.





Selected Publications

- *Catching up with Method and Process Practice: A new Baseline for Researchers* , *HELENA Consurtium , International Conference on Software Engineering in Practice, 2019*
- *Adopting Integrated Application Lifecycle Management within a Large-Scale Software Company: An Action Research Approach*, *Eray Tuzun, Bedir Tekinerdogan, Yagup Macit, Kursat Ince, Journal of Systems and Software, 2019*
- *An Auction-Based Serious Game for Bug Tracking* . *Cagdas Usfekes, Eray Tuzun, Murat Yılmaz, Yagup Macit, Paul Clarke, IET Software, 2019*
- *Closing the gap between software engineering education and industrial needs*, *Vahid Garousi, Görkem Giray, Eray Tüzün, Cagatay Catal, Michael Felderer , IEEE Software, 2019*
- *Adopting Augmented Reality for the Purpose of Software Development Process Training and Improvement: An Exploration*, *İpek Ohri, İrem Öge, Bora Orkun, Murat Yılmaz, Eray Tüzün, Paul Clarke, RV O'Connor , European Conference on Software Process Improvement, 195-206*
- *Adopting the Essence Framework to Derive a Practice Library for the Development of IoT Systems*,*Görkem Giray, Bedir Tekinerdogan, Eray Tüzün,Connected Environments for the Internet of Things, Challenges and Solutions, Springer International Publishing, 2018 (Book Chapter)*
- *IoT System Development Methods*,*Görkem Giray, Bedir Tekinerdogan, Eray Tüzün, Internet of Things: Challenges, Advances and Applications, CRC Press, 2018 (Book Chapter)*
- *Are Computer Science and Engineering Graduates Ready for the Software Industry? Experiences from an Industrial Student Training Program*
  Eray Tuzun, Hakan Erdogmus and Izzet Gokhan Ozbilgin, International Conference in Software Engineering SEET 2018

Database Research

Özgür Ulusoy

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

- **Web Databases and Search Engines**
- **Multimedia Databases**
- **Big Data and Social Network Analysis**

Web Databases and Search Engines

- Social Web search and personalization
- Domain-specific search engines
- Efficiency and scalability issues for Web Search Engines (caching, index pruning)
- Web information extraction
- Modeling and querying of Web resources
- XML querying & searching

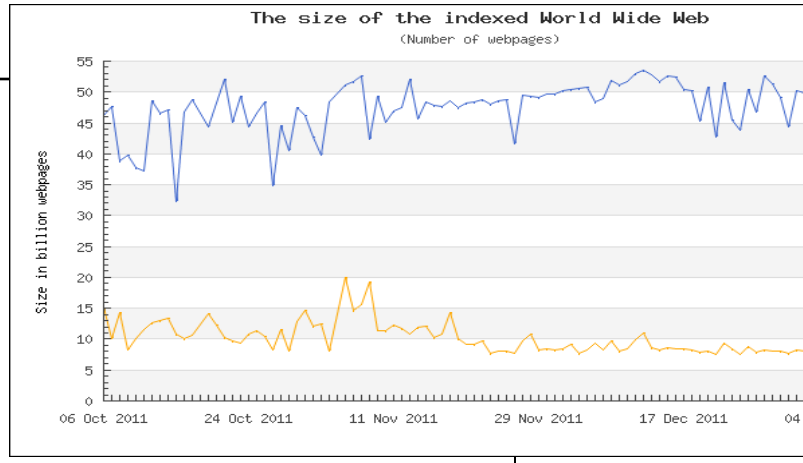
- ***http://www.cs.bilkent.edu.tr/~bilweb***

Search Engines are the key to access Web Data

1995 S. Brin meets L. Page

2000 First **billion-URL** index
The world's largest!
≈5000 PCs in clusters!

2008 Google counts **1 trillion** unique URLs



1995 — 2015

1998 Birth of Google

2004 Index grows to **4.2 billion** pages

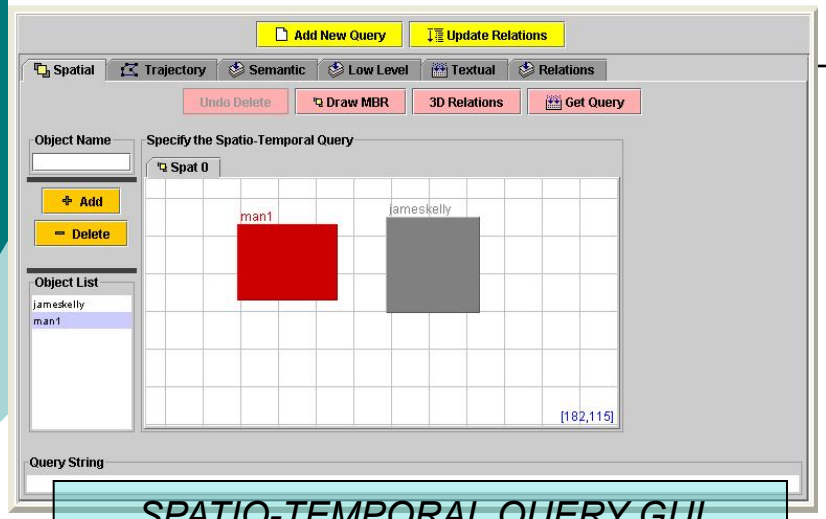
2009 TBs or PBs of data/index
Tens of thousands of PCs

Efficient and scalable strategies are of vital importance !

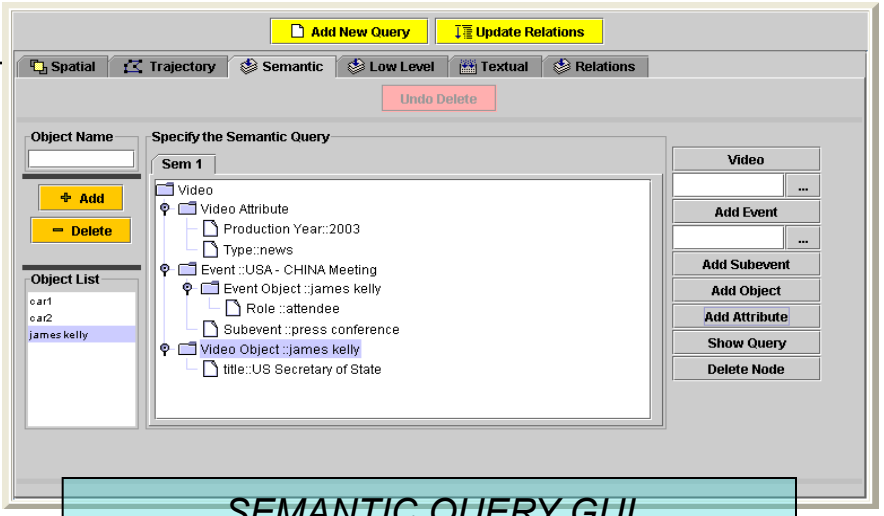
Multimedia Databases
(joint work with Prof. Uğur Güdükbay)

- Video Retrieval Systems
- Mobile Visual Search
- Ottoman Archive Content-Based Retrieval System
- ***http://www.cs.bilkent.edu.tr/~bilmdg***

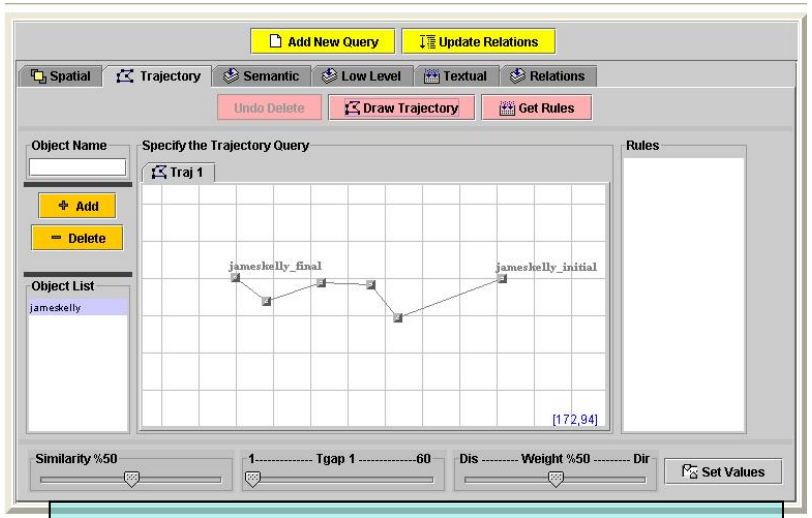
BilVideo: Integrated video DBMS supporting low-level, spatio-temporal, motion and semantic querying of videos



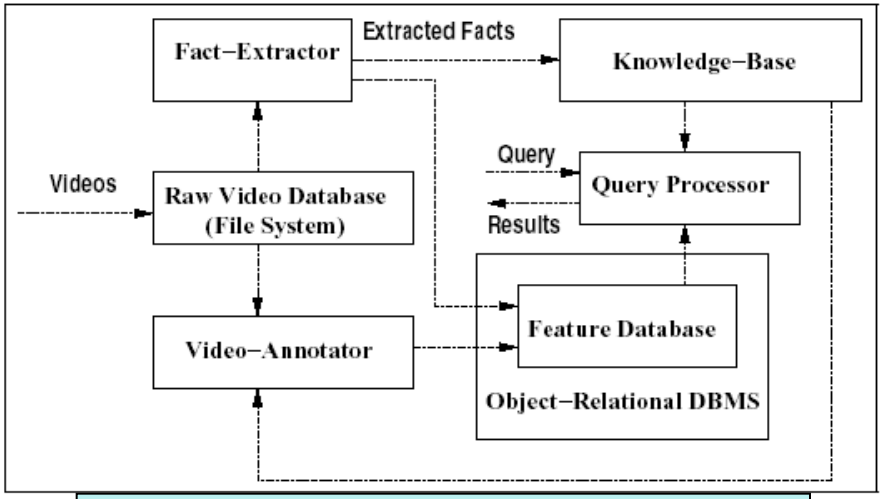
SPATIO-TEMPORAL QUERY GUI



SEMANTIC QUERY GUI

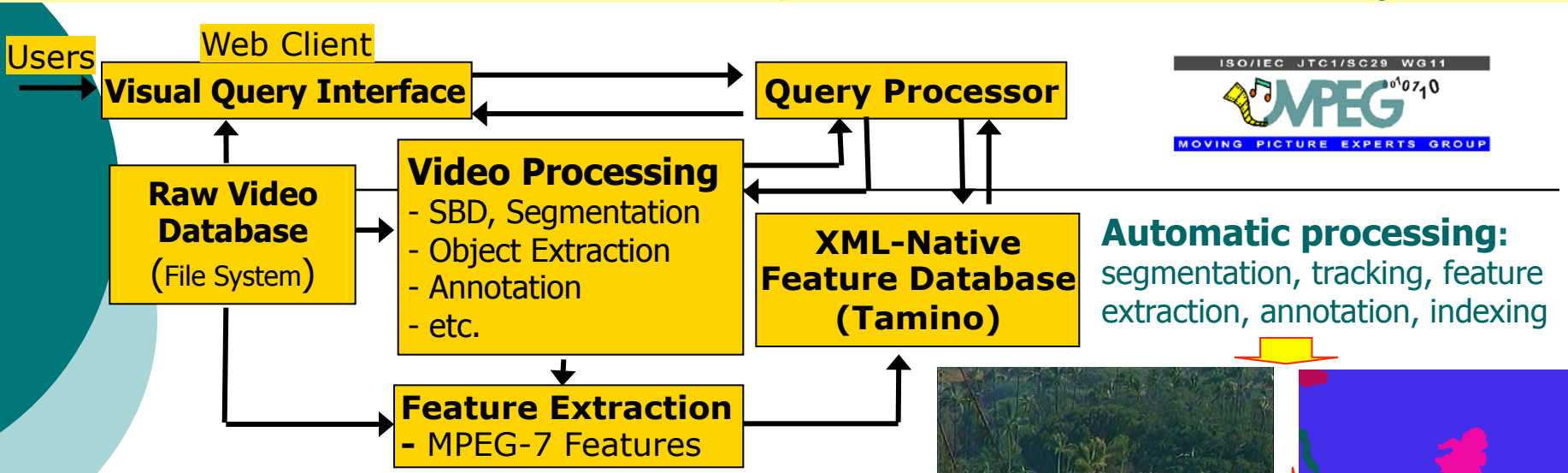


TRAJECTORY QUERY GUI



SYSTEM ARCHITECTURE

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

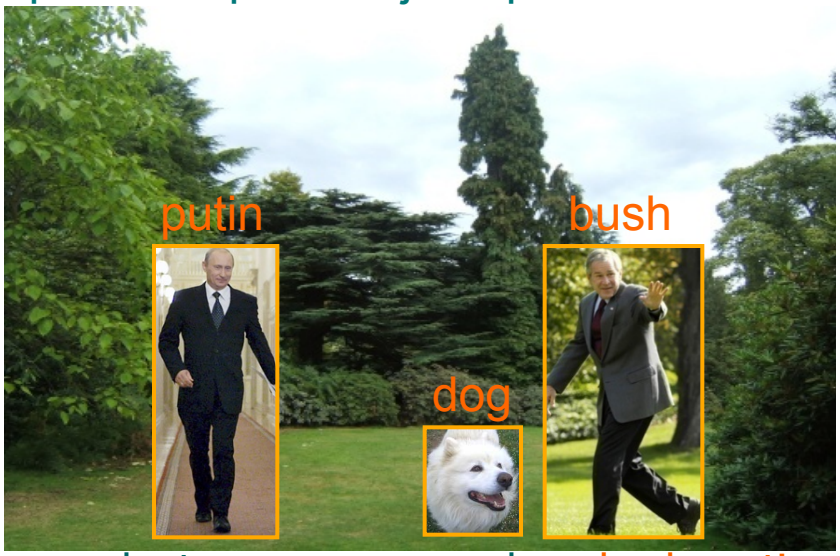


Automatic processing: segmentation, tracking, feature extraction, annotation, indexing

segmentation

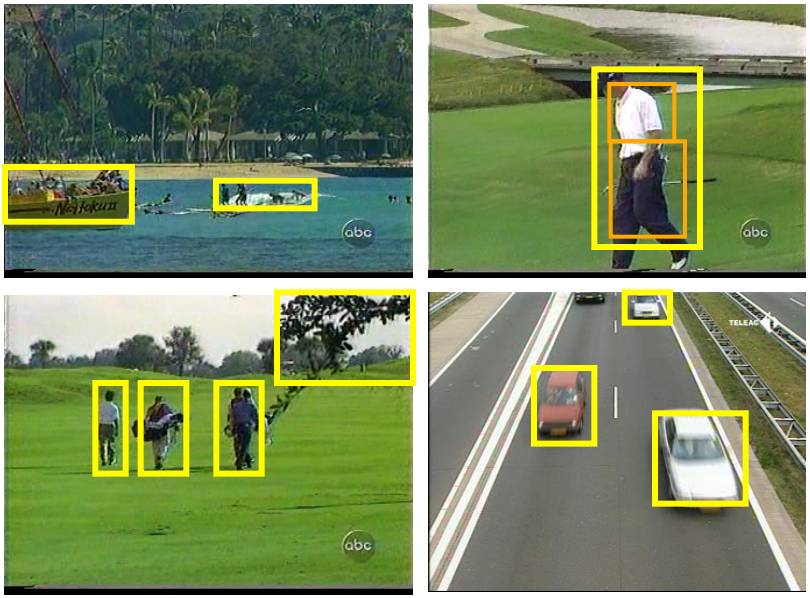
Powerful querying capability for video data

- keyword and content-based queries
- spatio-temporal object queries



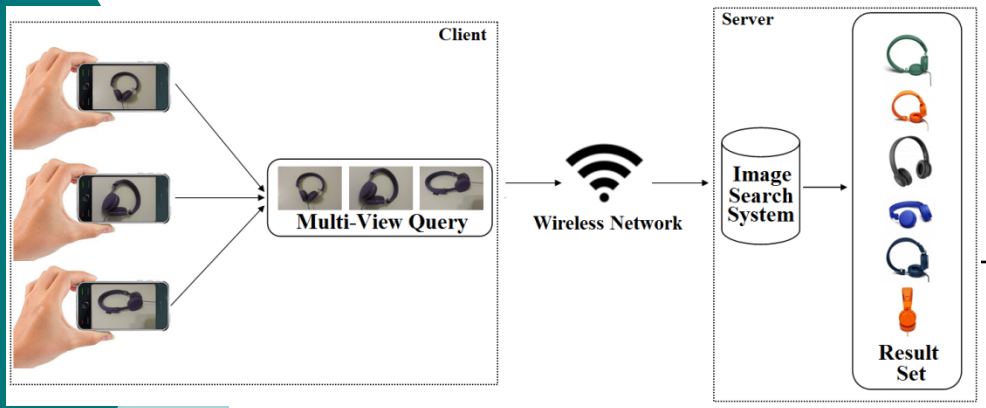
Example query formulation

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

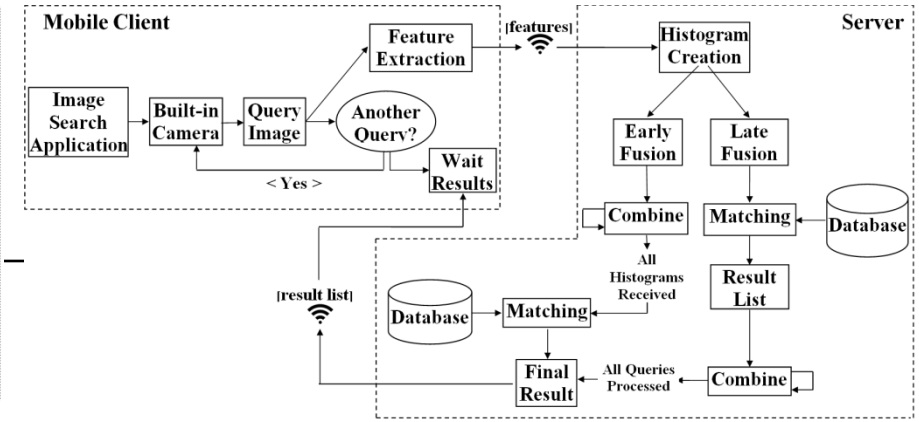


Salient video object extraction

Mobile Image Search Using Multi-Image Queries



Workflow of the Search System



Early and Late fusion methods

Dataset Images

Query Images

Multi-View Dataset and Queries

Single (a) and multi-view queries and corresponding result lists using early (b) and late (c) fusion methods.

Big Data and Social Network Analysis

- **Social Network Data Analysis on Big Data Processing Platforms**
  - **Development, implementation and evaluation of algorithms/methods to process/analyze social network data for various social network problems.**
    (joint work with Prof. İbrahim Körpeoğlu)
- **Decentralized Social Networks**
  - **Development, implementation and evaluation of algorithms/methods for peer-to-peer social networks.**
    (joint work with Prof. Hakan Ferhatosmanoğlu)