MultiModal Interaction Research @ Sabanci University

Berrin Yanıkoğlu

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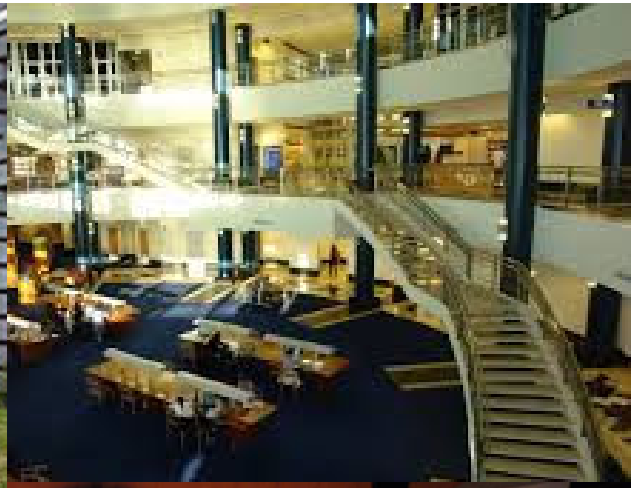
BAŞKENT ÜNİVERSİTESİ




Mevcut Araştırma Alanlarımız

Overview

- Medical Imaging
- Brain-Computer Interfaces
  - Gözde Ünal
  - Müjdat Çetin
- Visualisation
  - Selim Balcısoy
- Handwriting Recognition
- Multimodal biometrics
  - Berrin Yanıkoğlu

CGLab

Signal Processing and Information Systems Laboratory (SPIS Lab)

Signal Processing and Information Systems Lab. - Sabanci University

VPA Lab – http://vpa.sabanciuniv.edu/
CGLab – http://cglab.wordpress.com/
SPIS Lab - http://labs.sabanciuniv.edu/spis/

Gözde Ünal

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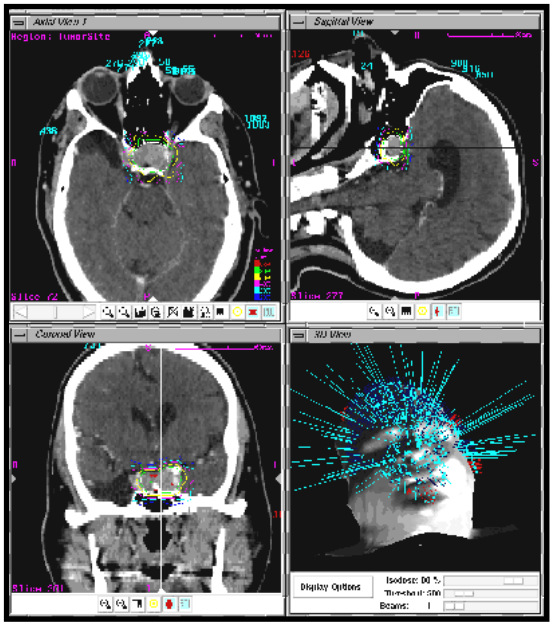
Visualization and Interaction are necessary for Surgical and Treatment Planning

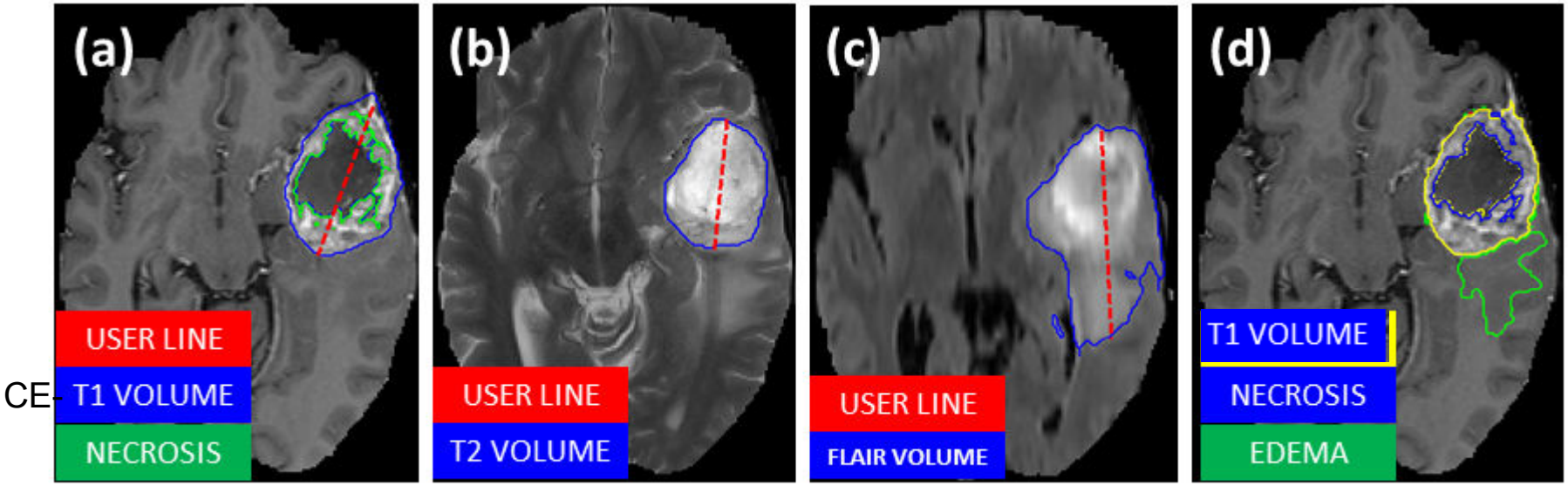
In Radiotherapy: detailed high-res 3D images of the patient are used for **outlining borders of the lesions during treatment planning**, as well as for **positioning of the patient during radiation delivery**



Funding: TÜBİTAK 1001 Research Grant (2009-2013)
Partners: Sabancı University, Assoc. Prof Gozde Unal
Clinical Partner:
Anadolu Medical Center, Prof. Dr. Kayhan Engin
RadioOncology Department
Dr. Kutlay Karaman, Radiology Department

For Interactive Tumor Segmentation, user draws a line on a 2D slice of different 3D MR volumes and the tumor is segmented

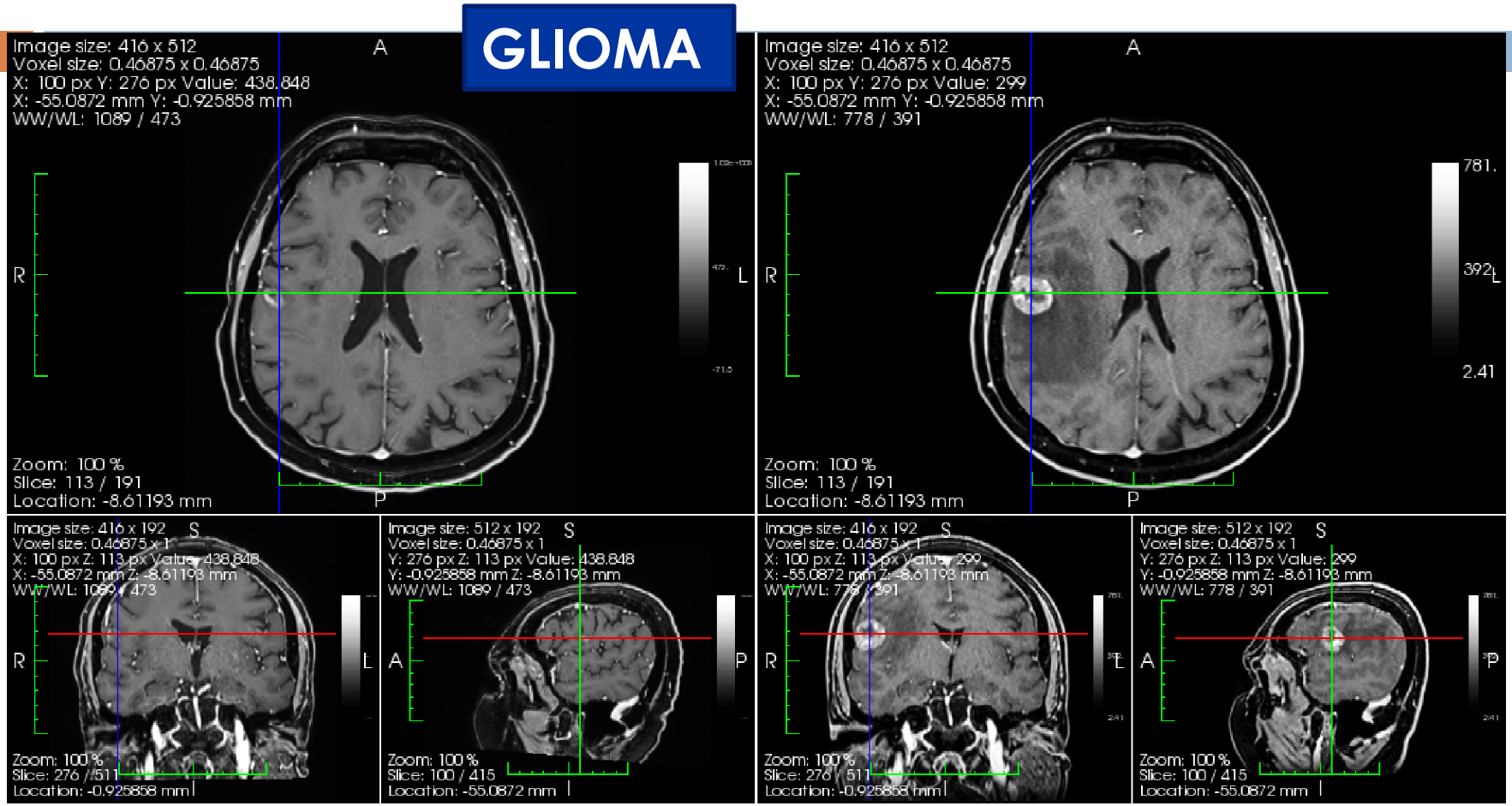
Tumor is segmented on different MR modalities (T1, T2, FLAIR, with and w/o contrast)



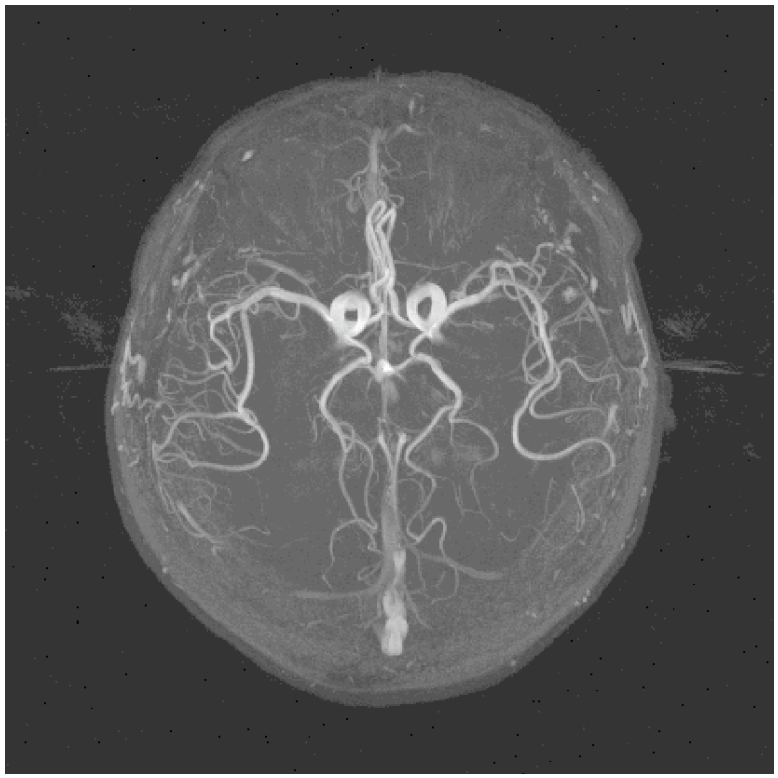
Hamamci A., Unal G.,.."Tumor-Cut: segmentation of brain tumors..." IEEE Transactions on Medical Imaging, 2012, 31(3):790-804.

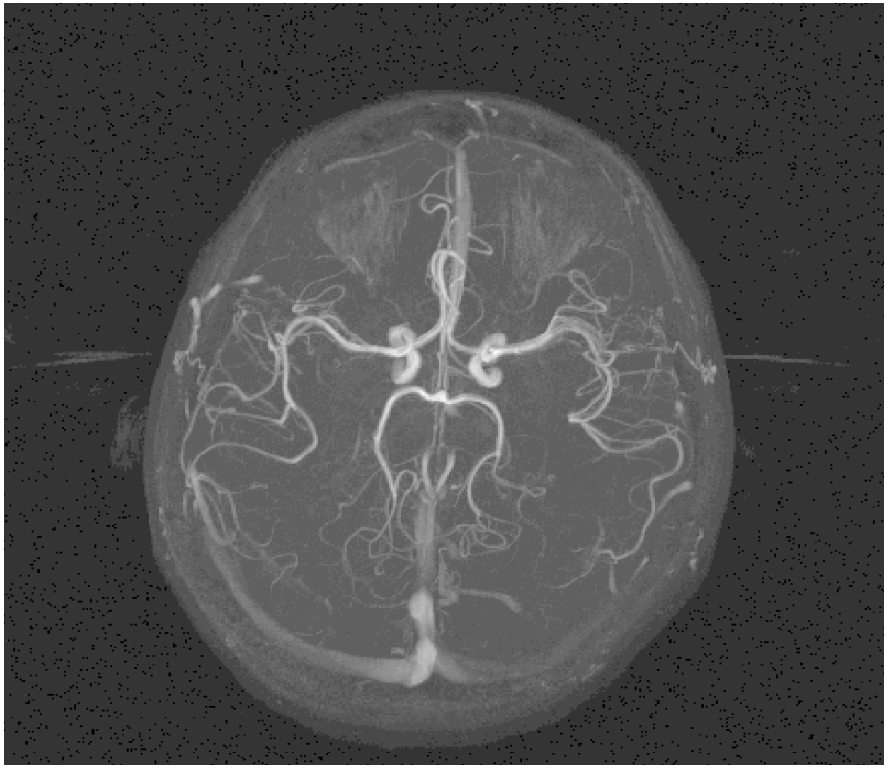
Hamamci A., Unal G., "Multimodal Brain Tumor Segmentation Using The Tumor-cut Method on the BraTS Dataset" MICCAI 2012-Multimodal Brain Tumor Segmentation Challenge.

Visualization of Anatomic Structures in Follow-up is important for comparison of pre/post therapy



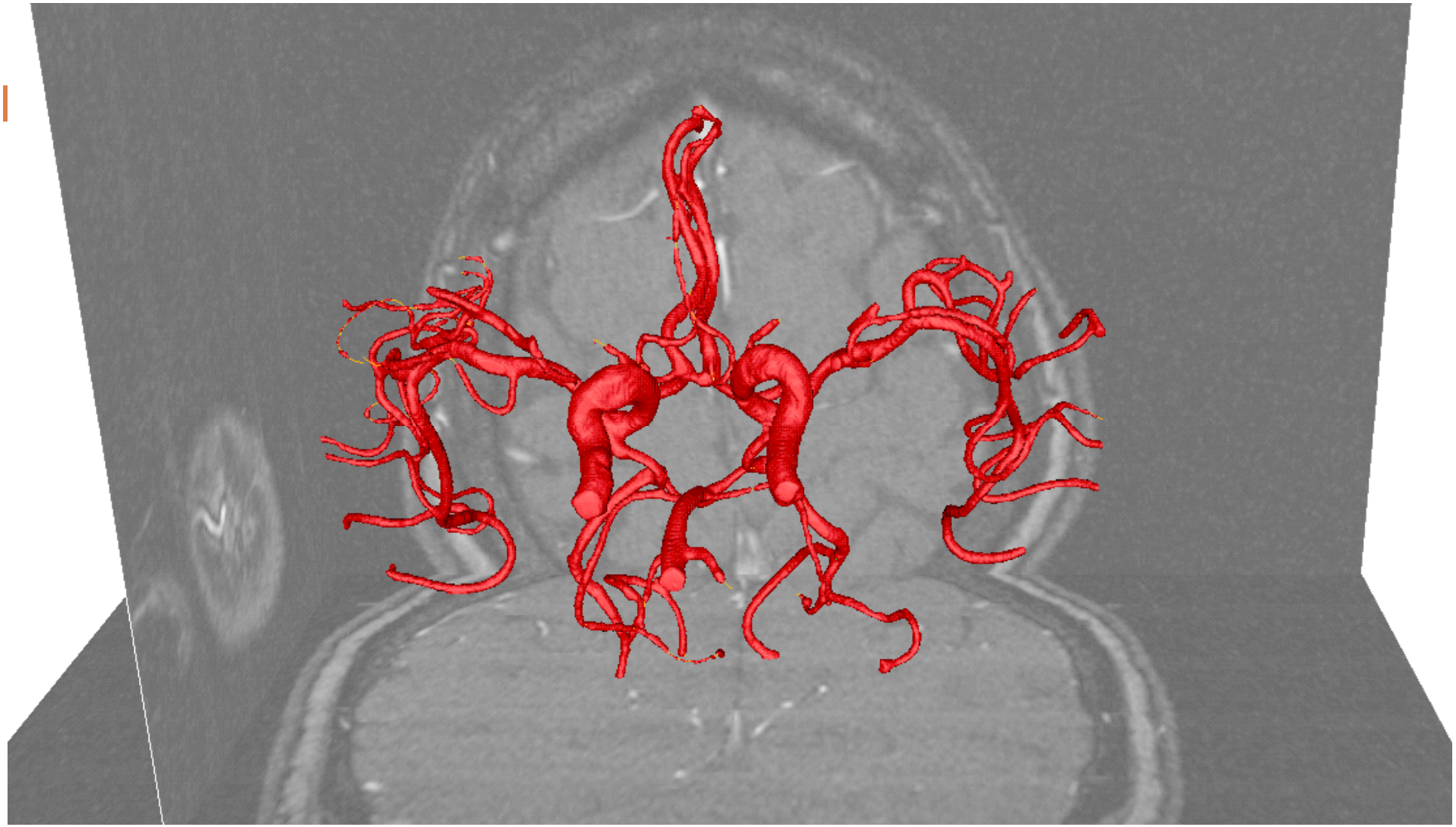
Brain Vasculature Modeling and Visualization is important for analyzing cerebral flow abnormalities





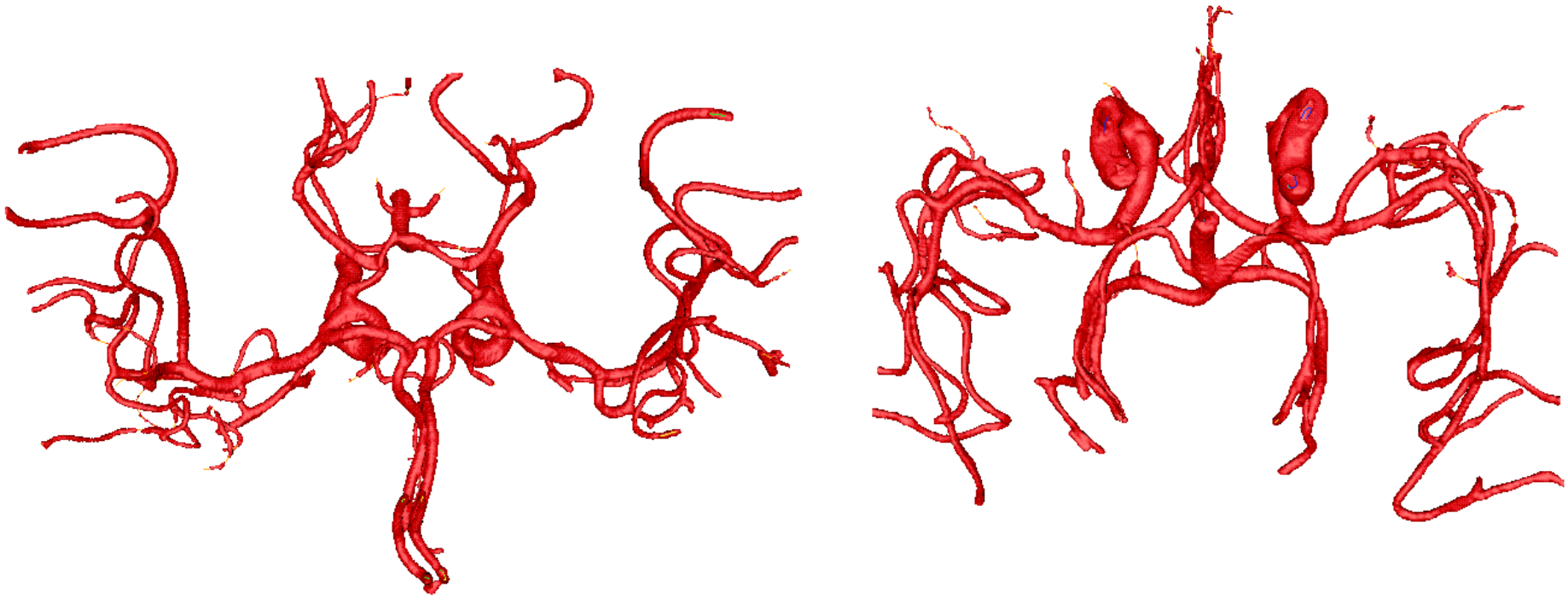
MIP: Maximum Intensity projection: Vessels are visible however, we do not know where they are in space, to do that segmentation and modeling is needed →

Cerebral Arteries Segmented from MRA and Modeled



* Cetin, S.., Unal G.,.."Vessel tractography using an intensity based tensor model with branch detection " IEEE Transactions on Medical Imaging, 2013, 32(2):348-63

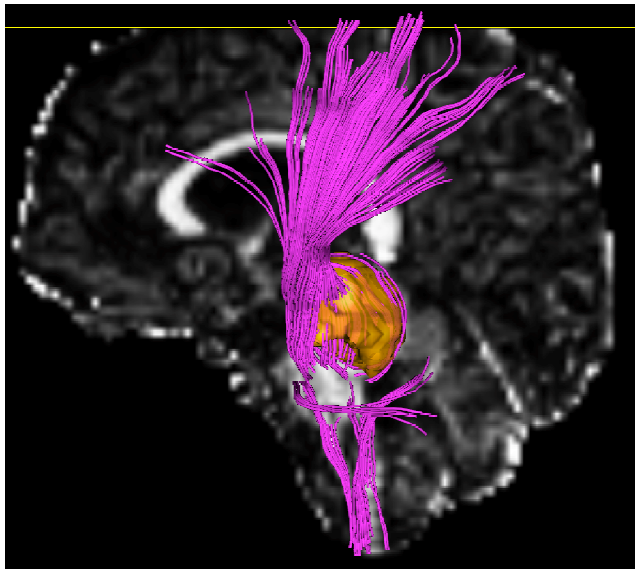
These Vessel models are then used for: surgical planning pathology detection and quantification

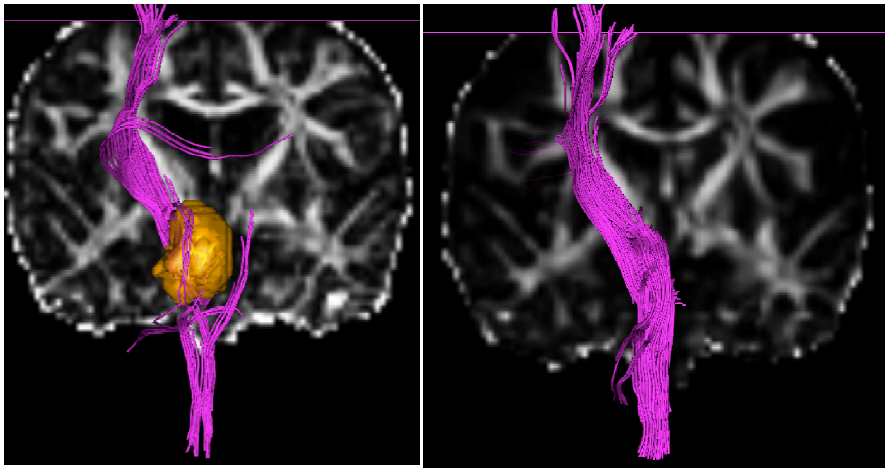


Pre-Post Op DTI for BrainStem Lesion Follow-up

Computational Tools for **Assessment of Brain Stem Lesion Surgery Follow-up** are developed:

- BrainStem White Matter Structures are revealed along with pathology, i.e. the tumor
- Brain surgeon uses these for planning surgery too





Before Surgery After Surgery

Funding: TÜBİTAK 1001 Research Grant (2013-2016)
Partners: Sabancı University, **Assoc. Prof Gozde Unal**
Clinical Partner:
Yeditepe University Hospital, Prof. Dr. Uğur Ture
NeuroSurgery Department
Zeynep Fırat, Radiology Department

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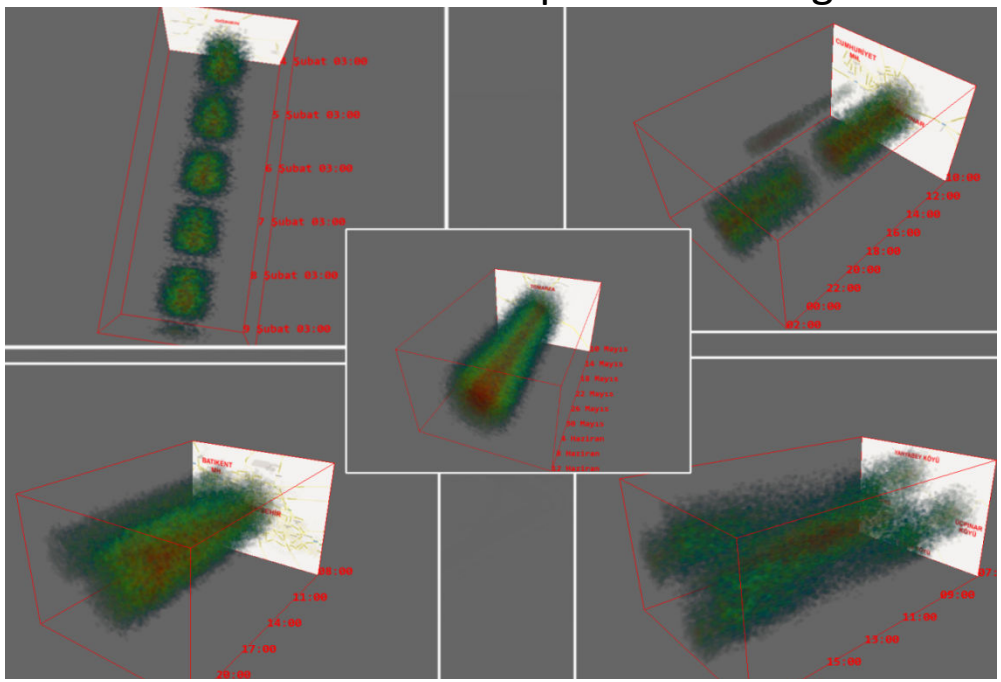
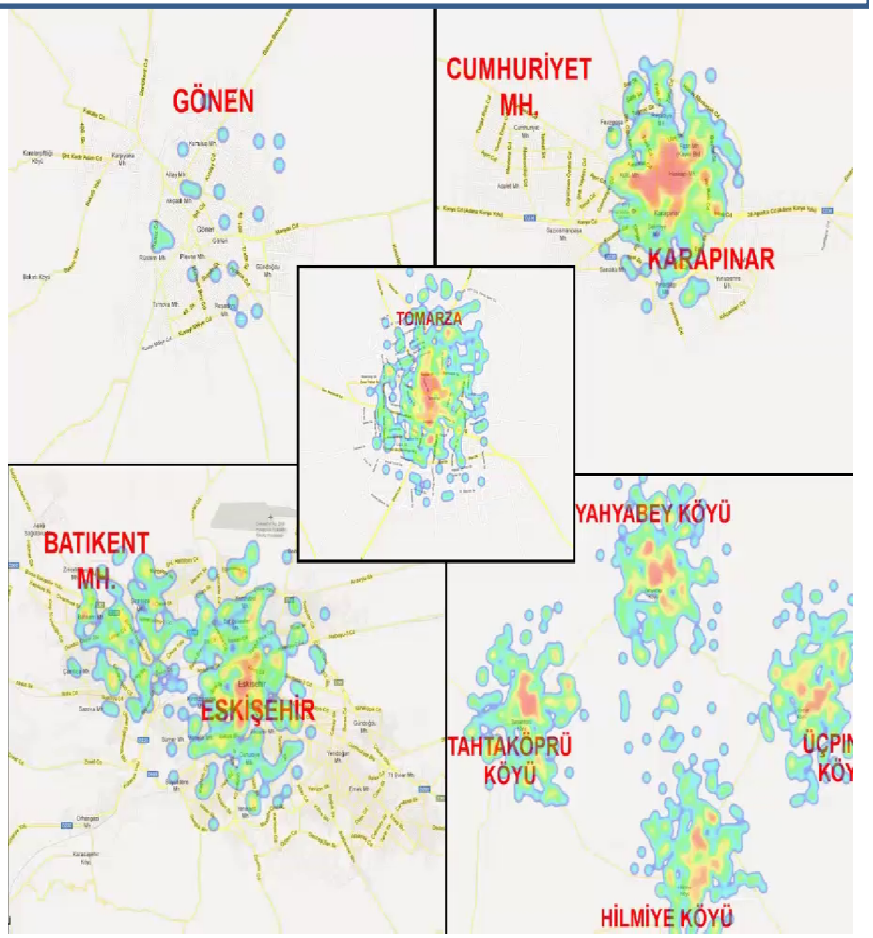
Spatio-temporal data analysis

Do 3D Visualizations Fail? An Empirical Discussion on 2D and 3D Representations of the Spatio-temporal Data

Erdem Kaya, M. Tolga Eren, Candemir Doger, **Selim Balcisoy**. IEEE SciVis 2014, Poster Presentation

- Analysis of spatio-temporal data has become critical with the emergence of ubiquitous location sensor technologies.
  - One application area is location based services (LBS) for GSM networks and another area is shipment tracking.





Video: http://vimeo.com/103168572

Spatio-temporal data analysis

Light Source Estimation in Mobile Augmented Reality Scenes by Using Human Face Geometry

Emre Koç, Selim Balcisoy, IEICE Transactions Vol. 97-D No. 8 Pg. 1974-1982

- Light source estimation and virtual lighting must be believable in terms of appearance and correctness in augmented reality scenes. As a result of illumination complexity in an outdoor scene, realistic lighting for augmented reality is still a challenging problem.

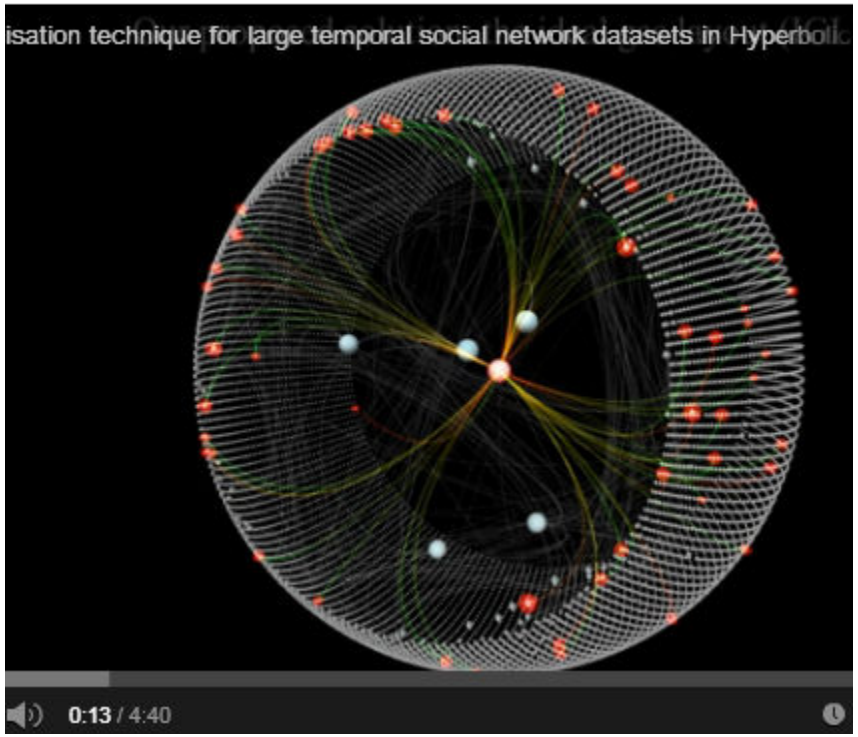
- In this paper, we propose a framework based on an estimation of environmental lighting from well-defined objects, specifically human faces.

Spatio-temporal data analysis

A visualisation technique for large temporal social network datasets in Hyperbolic space

Uraz Cengiz Türker, **Selim Balcısoy**, Journal of Visual Languages & Computing, 2014

- In this paper, we present a novel visualisation approach that depicts both relational and statistical information of evolving social structures.
- The underlying framework is implemented by the usage of *Hyperbolic Geometry* to support focus context rendering.
- The proposed method guarantees representing prominent social actors through scaling their representations, preserves user's mental map, and provides the user to reduce visual clutter by means of filtering.



Augmented Reality

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Objective

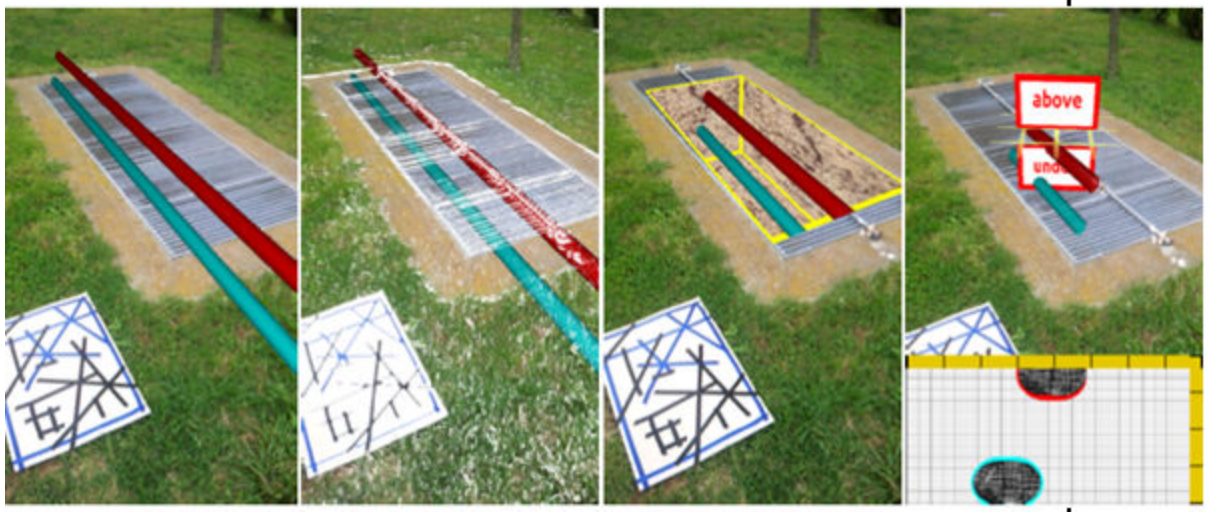
See what is behind and beneath

Significance

- Explore what is around
- Understand the real world
- And use only with a mobile phone

Results

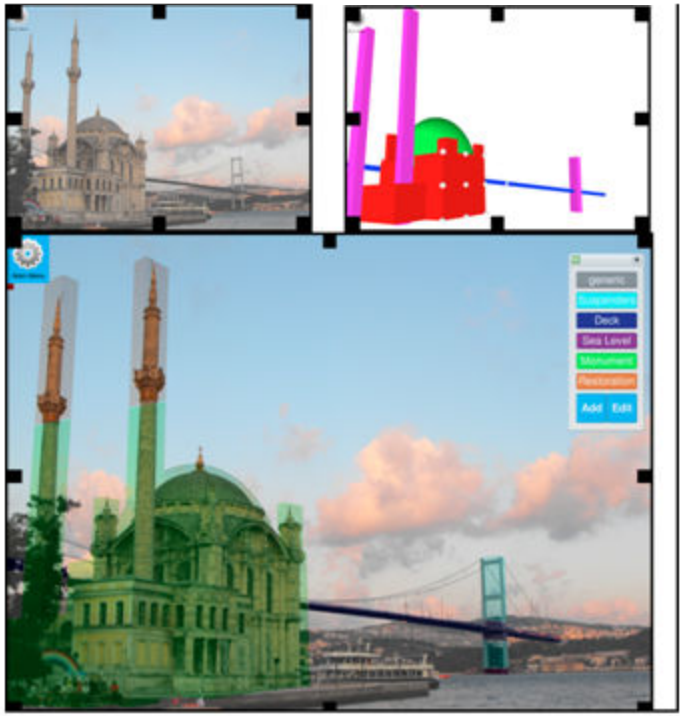
- Two Turk Telekom and three TUBITAK projects. Two of them with Italian Universities.



Approach & Use Cases

- Advanced Computer Graphics, Computer Vision techniques and localization sensors (GPS, Accelerometers and Gyroscope) enable Augmented Reality experience.

- Municipalities, Defense and Cultural Heritage



Big Data Visualization and Analytics

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Objective

To understand trends and anomalies in big data with visualizations

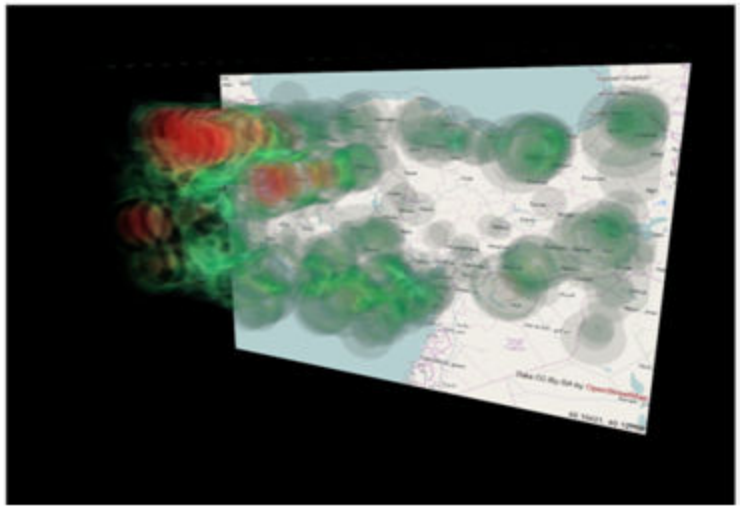
Significance

What to do when you don't know the question ?

What is a trend ? What is an anomaly ?

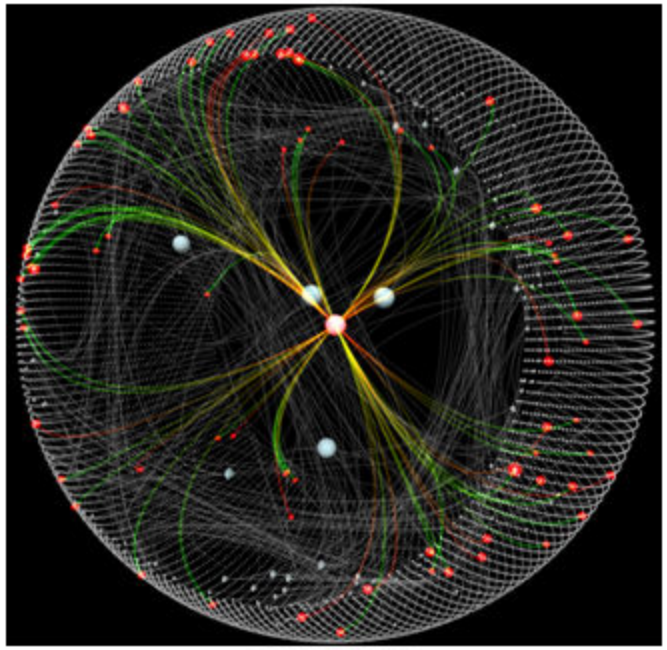
Results

• One TUBITAK and one Sabanci University Internal Grant projects.



Approach and Use Cases

- Computer Graphics and Data Visualization techniques are used together with Social Network Analysis
- Location Data and Time
  - Spatio-temporal data visualization
  - Real-time Visual Analytics
  - Trend and Anomaly Detection
- Social Network Visualization
  - Inner workings of a organization.
  - Homeland Security and Fraud



Müjdat Çetin

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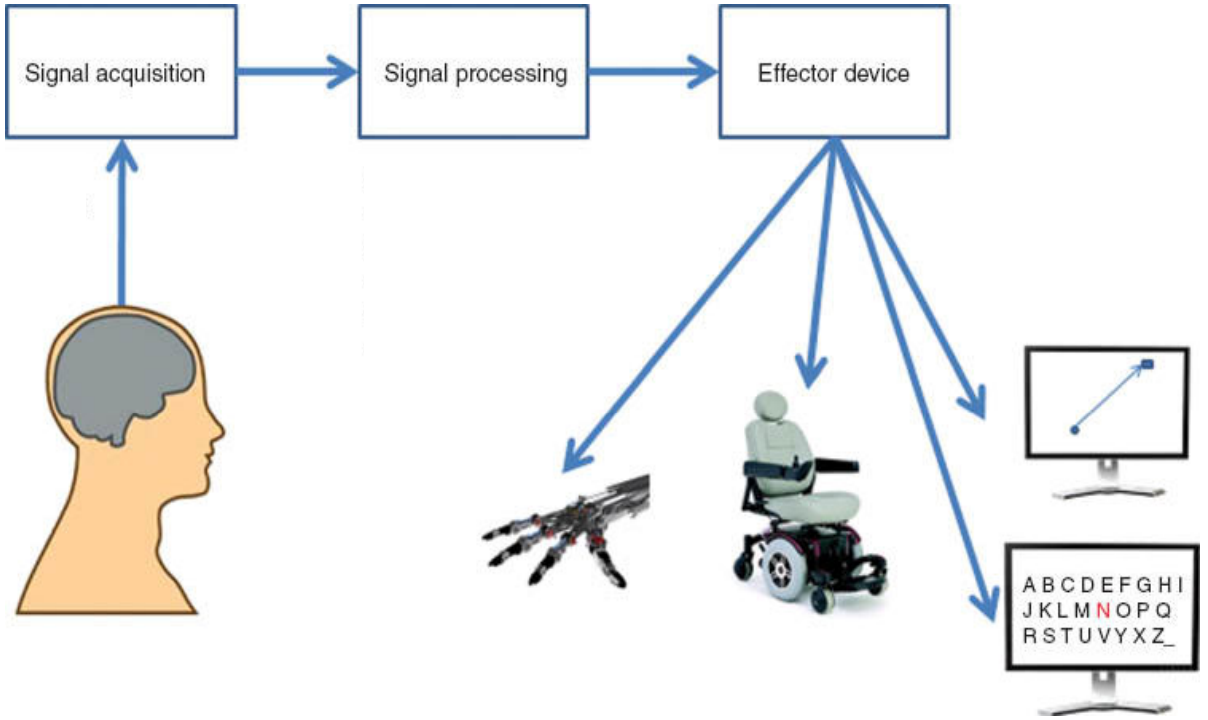
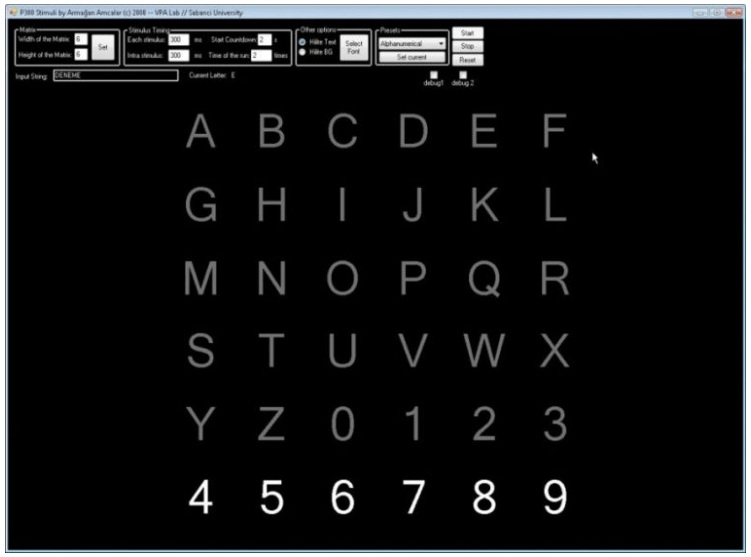
EEG-based Brain-Computer Interfaces (BCI) work at Sabancı University



- BCI-based spelling using P300 signals and language models
- New models and algorithms for classification of imaginary motor tasks
- BCI-based robotic rehabilitation *[involving a collaboration with MPI Intelligent Systems Tübingen]*

BCI-based Spelling System

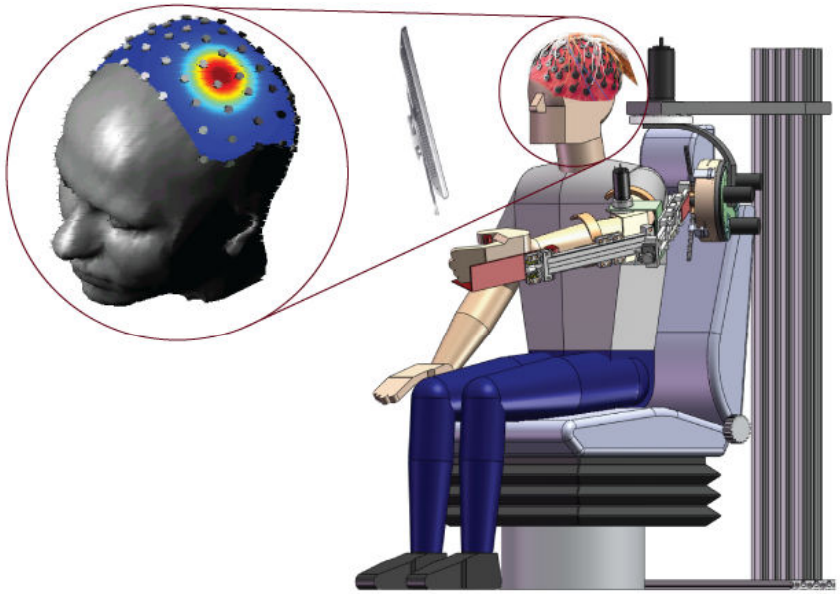
Joint use of EEG data and language models



J.F. Delgado Saa, A. de Pesters, D. McFarland, and M. Çetin, "A Probabilistic Graphical Model for Word-Level Language Modeling in P300 Spellers," International Brain-Computer Interface Conference, 2014.

Ç. Ulaş and M Çetin, "Incorporation of a Language Model into a Brain Computer Interface based Speller through HMMs," IEEE International Conference on Acoustics, Speech, and Signal Processing, 2013.

Controlling Robotic Movements using Brain Signals for Stroke Rehabilitation

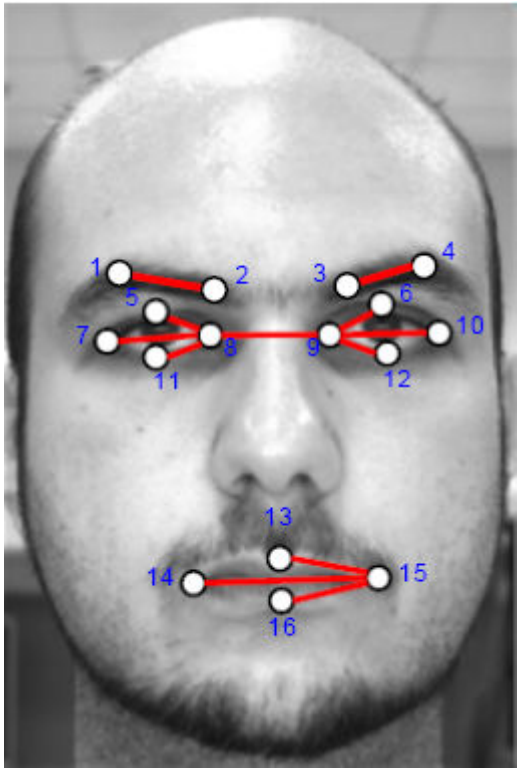


Using "movement intention" continuously detected from EEG to control the robot

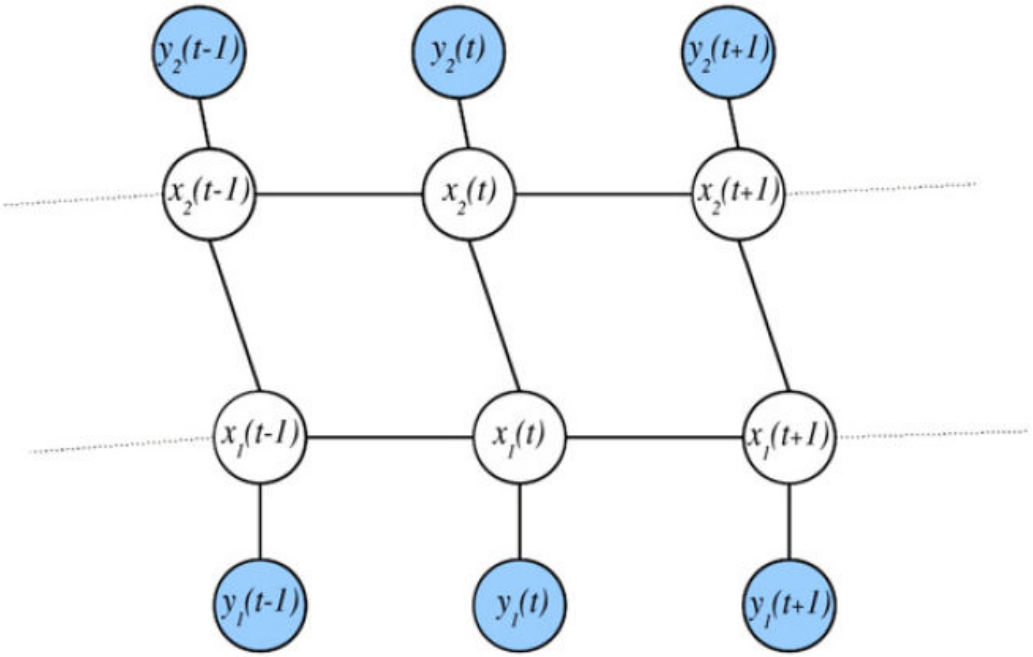
M. Saraç, Ela Koyaş, A. Erdoğan, **V. Patoğlu**, and **M. Çetin**, "Brain Computer Interface based Robotic Rehabilitation with Online Modification of Task Speed," *International Conference on Rehabilitation Robotics*, 2013.

O. Özdenizci, T. Meyer**, M. Çetin**, and M. Grosse-Wentrup, "Towards Neurofeedback Training of Associative Brain Areas for Stroke Rehabilitation," *International Brain-Computer Interface Conference*, 2014.

Facial Feature Tracking using Graphical Models



Using spatio-temporal graphical models for jointly tracking multiple facial features



S. Coşar and M Çetin, "A Graphical Model based Solution to the Facial Feature Point Tracking Problem," Image and Vision Computing, 2011.

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Computer Vision: Handwriting & Sketch Recognition

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Objective

Automatically recognize handwritten text or sketches: online or offline

Significance

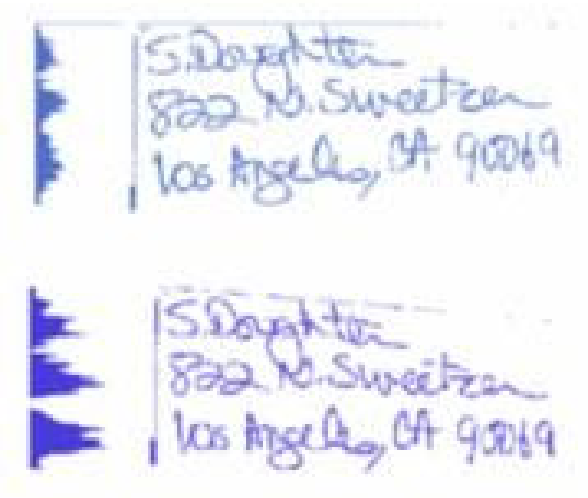
- Easy and natural interface alternative to keyboards
- Scanned document recognition helps extract information and speedup document processing.

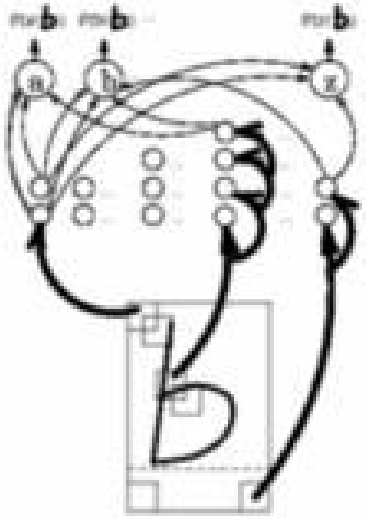
Results

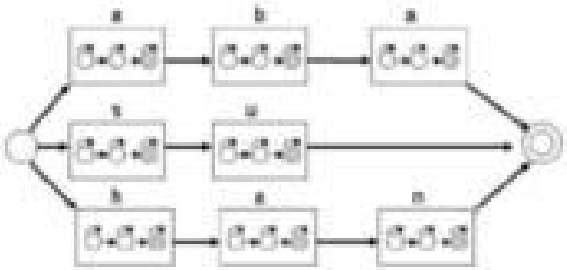
- Developed techniques to recognize handwritten Turkish documents which poses extra challenges

Approach

- Hidden Markov Models
- Neural Networks, SVM classifiers
- Deep Learning (LSTM architecture)
- Language Models







Handwriting Recognition (English and Turkish)

Sketched symbol recognition with auto-completion. Caglar Tirkaz, Berrin A. Yanikoglu, T. Metin Sezgin, *Pattern Recognition* 45(11): 3926-3937 (2012).

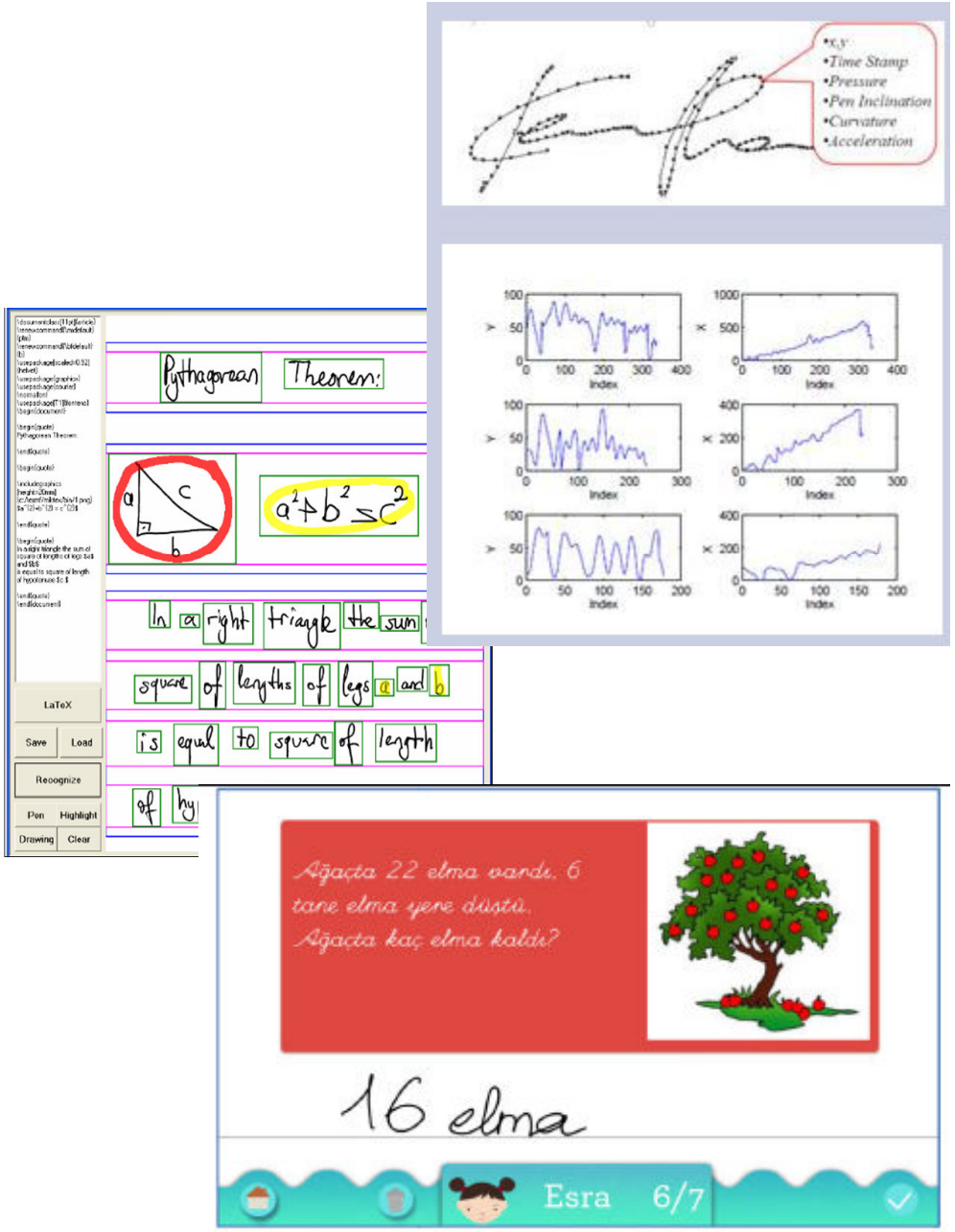
Memory conscious sketched symbol recognition. Caglar Tirkaz, Berrin A. Yanikoglu, T. Metin Sezgin: ICPR 2012: 314-317

Probabilistic Mathematical Formula Recognition Using a 2D Context-Free Graph Grammar, Mehmet Celik, Berrin A. Yanikoglu, ICDAR 2011: 161-166

Online handwritten mathematical expression recognition, Hakan Büyükbayrak, Berrin A. Yanikoglu, Aytül Erçil: DRR 2007

An online handwriting recognition system for Turkish, Esra Vural, Hakan Erdogan, Kemal Oflazer, Berrin A. Yanikoglu, DRR 2005: 56-65

Turkish handwritten text recognition: a case of agglutinative languages, Berrin A. Yanikoglu, Alisher Kholmatov, DRR 2003: 227-233



Biometrics: Signature, Fingerprint Verification, Privacy

Berrin Yanıkoğlu (berrin@sabanciuniv.edu)

Objective

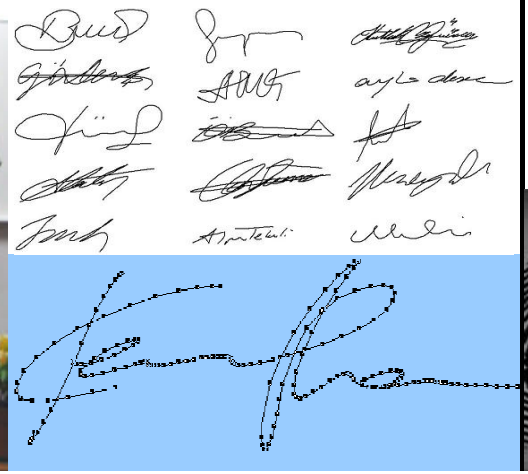
To verify or recognize people through their biometric data.

Significance

- Eliminate need for tokens or passwords.
- Increased security compared to passwords or tokens.

Results

- Our signature verification systems obtained several first place results in international competitions.
- Proposed novel privacy preserving template framework



Approach

Developed state-of-art fingerprint & signature verification systems and schemes for privacy preserving biometrics.

- **Signatures**
  - Dynamic Time Warping
  - Spectral Analysis (Fourier Transform)
  - Histogram of Oriented Gradients
  - Local Binary Pattern
  - Support Vector Machines
- **Fingerprints**
  - Minutiae-based approaches
  - Spectral minutiae
- **Privacy Preserving Biometrics**
  - Combining multiple fingerprints at template level increases both privacy and security.

Multimodal Biometrics

- Multi-modal biometrics and Biometric privacy are both attraction attention.
- While a few bio-crypto frameworks exist, they fall short in lights of the fuzzy nature of biometrics.
- Our solution suggest the use of multimodal biometrics for increased security and privacy (template protection, unlinkeability, …)

Multi-biometric templates using fingerprint and voice, E Camlikaya, A Kholmatov, B Yanikoglu
SPIE Defense and Security Symposium, 2008.

Combining multiple biometrics to protect privacy, B Yanikoglu, A Kholmatov
ICBA Workshop Proceedings, 43, 2004