

# Automatic Analysis of Large Volume Eye-tracking Data

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**PeWe@FIIT**  
personalized web group

# Our background

- PhDs in software engineering
- Focusing on analyzing human behavior in digital environments
- Personalized web group
  - <http://pewe.fiit.stuba.sk>



# User knowledge modeling

The screenshot shows the AleF LMS interface. At the top, there is a navigation bar with a home icon, the AleF logo, and tabs for Administration, SI, Lisp, and C. The user is identified as Marian Simko (administrator) with a Log out link.

The main content area is titled "Funkcia CONS". It includes a "Filter" bar with icons for search, checkmarks, and other filters. The text explains the CONS operation: "Operácia CONS na základe dvoch argumentov: s-výrazu a zoznamu, vytvára nový zoznam, ktorého prvý prvok je s-výraz a ostávajúce prvky tvoria prvky pôvodného zoznamu." It also provides a scheme for the arguments: "(CONS nový-prvý-prvok zoznam)".

An example is given: "Napríklad:" followed by a code block: 

```
* (CONS 7 '(2 14))  
(7 2 14)  
* (CONS '(1 2) '(3 (4)))  
((1 2) 3 (4))  
* (CONS 14 NIL)  
(14)
```

The second argument is described as "Druhý argument (s výrazom) je typu zoznam. Takže napr. funkcia (CONS 5 8) nie je priamo definovaná." It notes that the CONS operation is inverse to FIRST and REST operations.

A second code block shows: 

```
* (FIRST '(7 2 14))  
7
```

Annotations on the page include:

- 1: A yellow circle highlighting the "Recommended" sidebar menu.
- 2: A yellow circle highlighting the "Exercises" tab in the sidebar.
- 3: A yellow circle highlighting the example code block.
- 4: A yellow circle highlighting the "Your score" widget showing 52.3%.
- 5: A yellow circle highlighting the "Reported errors" widget showing no errors.
- 6: A yellow circle highlighting the "Tags" widget with "CONS funkcia" tag.
- 7: A yellow circle highlighting the "External sources" widget with links to Wikipedia and AleF resources.



# User interest modeling



umap

Search

About 357,000 results (0.29 seconds)

[Advanced search](#)

Everything

More

Any time

[Past 2 days](#)

More search tools

Results provided by peweproxy: [umap 2010](#) , [UMAP 2011](#) , [umap conference](#)

[UMAP 2010 - User Modeling, Adaptation and Personalization](#)

**UMAP 2010** - 18th Intl. **Conference** on User Modeling, Adaptation and Personalization. ... Plan your **conference** schedule and share your thoughts using the **UMAP** ...  
<http://www.hawaii.edu/UMAP2010/> - [Cached](#)

[UMAP 2010 - Workshops and Tutorials](#)

**UMAP 2010** - 18th Intl. Conference on User Modeling, Adaptation and Personalization.  
<http://web41.its.hawaii.edu/www.hawaii.edu/UMAP2010/index.php/workshops-and-tutorials> - [Cached](#)

[Home | UMAP2009](#)

**UMAP** is the most important **conference** for those interested in any aspect of ... The **UMAP 2009 conference** was held in the week of June 22nd, 2009. ...  
<http://umap09.fbk.eu/> - [Cached](#)

[UMAP Thailand Short Course 2010 | Office of International Affairs](#)

Ian Hoskins on **UMAP** Thailand Short Course 2010; dizz on **UMAP** Thailand Short Course 2010; Elita on Kokushikan University Exchange Program **2011** ...  
<http://oia.ugm.ac.id/interface/?p=407> - [Cached](#)

Results for: **umap**

[UMAP - University Mobility in Asia and the Pacific](#) ☆

Invitation to **UMAP** Participating Universities to Join the **UMAP** Student Connection Online [USCO] Full Features 2/2010, for student exchanges & credeit ...  
[www.umap.org/](http://www.umap.org/) - 11 hours ago - [Cached](#) - [Similar](#)

[UMAP 2010 - User Modeling, Adaptation and Personalization](#) ☆ - 12 visits - Apr 8

**UMAP 2010** - 18th Intl. Conference on **User Modeling, Adaptation and Personalization**.  
[www.hawaii.edu/UMAP2010/](http://www.hawaii.edu/UMAP2010/) - [Cached](#) - [Similar](#)

[UMap \(AS 3.0\) - Advanced Flash Components](#) ☆

**UMap** API has moved. Visit UMapper to download the latest version of **UMap**. ... One of the



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# Question routing in CQAs

The screenshot shows the Stack Overflow homepage. At the top, there is a navigation bar with 'StackExchange' and links for 'sign up', 'log in', 'tour', 'help', and 'stack overflow careers'. A search bar is on the right. Below the navigation bar is the 'stackoverflow' logo and a row of buttons: 'Questions', 'Tags', 'Users', 'Badges', 'Unanswered', and 'Ask Question'.

The main content area features a introductory section with the text: 'Stack Overflow is a question and answer site for professional and enthusiast programmers. It's 100% free, no registration required.' Below this is a 'Take the 2-minute tour' button. To the right, under 'Here's how it works:', there are three icons and text: 'Anybody can ask a question', 'Anybody can answer', and 'The best answers are voted up and rise to the top'.

Below the introductory section is the 'Top Questions' section, which is currently filtered by 'interesting' (392 questions). The list of questions includes:

- 0 votes, 0 answers, 2 views: **Magento StoreView specific .htaccess** (tags: .htaccess, magento, ip, block) asked 1 min ago askraba 1
- 0 votes, 0 answers, 2 views: **Checking Subflows in Multipath TCP Connection** (tags: linux, tcp, linux-kernel, network-programming, ubuntu-14.04) asked 1 min ago Novak007 57
- 0 votes, 0 answers, 2 views: **SWF Loader -> TypeError: Error #1009 (Null reference)** (tags: actionscript-3, flash, flash-cs6) asked 1 min ago user3307017 1
- 0 votes, 0 answers, 2 views: **Insert multiple items to one column in sql and get them one by one** (tags: c#, sql, winforms, select, insert) asked 1 min ago Selguk AYDIN 6
- 0 votes, 0 answers, 2 views: **Rails iterated query to SQL statement** (tags: sql, ruby-on-rails, ruby, postgresql) asked 1 min ago Richardlonesteen 137
- 0 votes, 0 answers, 2 views: **Outlook 2003 with IMAP account sends unexpectedly "return receipts"** (tags: email, outlook, imap, receipt) asked 2 mins ago Jili 1
- 0 votes, 0 answers, 5 views: **change password bcrypt with hash and salt on ruby on rails 4.2** (tags: ruby-on-rails-4.2, change-password, bcrypt-ruby, saltedhash) modified 2 mins ago Felipe Eduardo Rojas 1
- 0 votes, 0 answers, 23 views: **How to properly set up a Grails update controller to avoid null pointer exception?** (tags: angularjs, grails) modified 2 mins ago Burt Beckwith 56.3k

On the right side, there is a 'Looking for a job?' section with job listings for 'Senior .NET Web Developer (m/f) bwin.party digital enterta...' and 'Software Engineer, Rails HappyFresh'. Below that is a 'Hot Network Questions' section with a list of trending questions.



# Deception/focus detection

- Automatically decide upon nature of human-computer interaction
  - Filling of web-based questionnaires
- How reliable are the answers?
  - Did our user pay attention to questions?
  - Did she tried to deceive us?



# User interaction analysis

- Focus beyond user interface
- Analyzing all kinds of digital footprints on the Web
  
- Social Web
- Adaptive Web
  - Predictive Web
  
- We need to model our users



# Machine Learning

- Where explicit rules are not applicable
- Let a program to learn dependencies/connections within data
- train/test model on available data
- use model to predict/classify new data





# Machine Learning

- Supervised
  - data with labels
    - user logs + “deceiving” or “telling the truth” label
  - task: find mapping of input to output
  - classification, regression
- Unsupervised
  - task: find a structure within data itself



# Supervised learning

- Describe individual observations through a set of features
  - time spent on a task / between clicks
  - average length of a visit
  - number of rated items
  - ...
- Find such a combination of these features (using a learning algorithm) that would produce minimal error in classification/prediction

# Supervised learning – features and labels

- Which features to choose?
- How many of them?
- How many labeled observations do we need?
  - Acquiring them requires human effort

# Unsupervised learning

- We do not need labelled data
  - that means we can use tons of them for our model
- We are looking for an implicit structure/connections present within data
  - cluster, groups



# Unsupervised learning

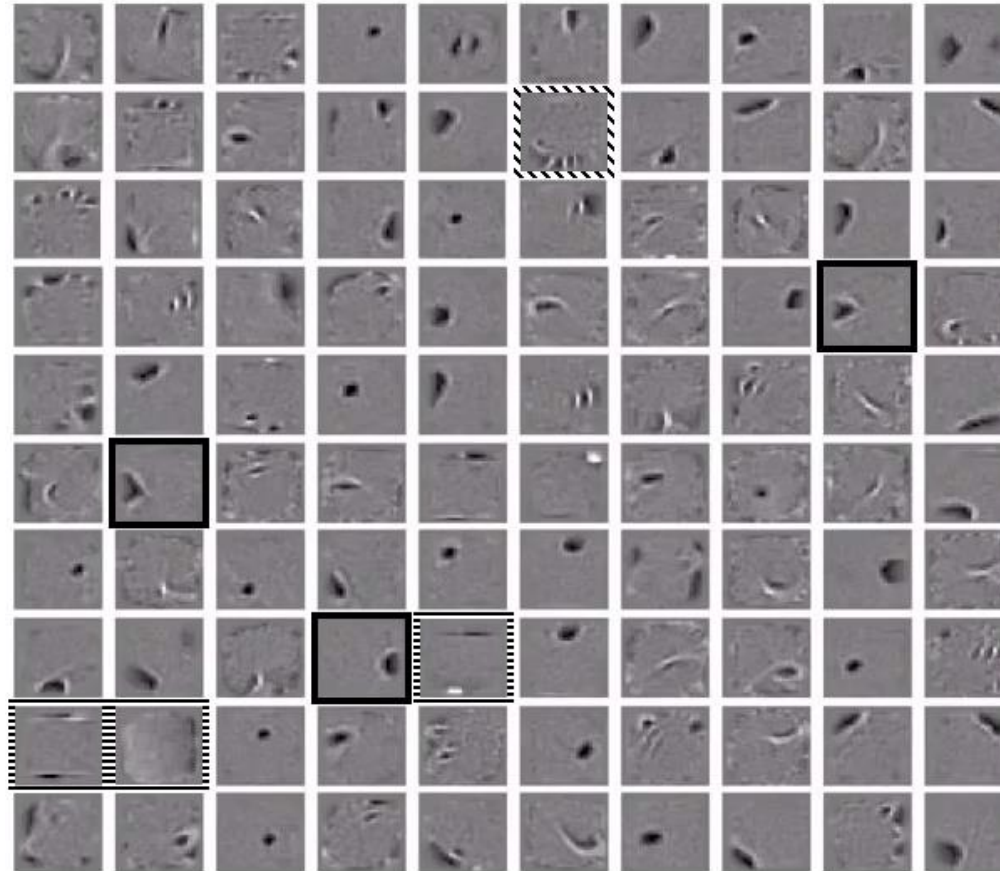
- We do not need labelled data
  - that means we can use tons of them for our model
- We are looking for an implicit structure/connections present within data
  - cluster, groups
- We can “learn” features which are suitable for supervised learning
  - This is how humans are learning things!



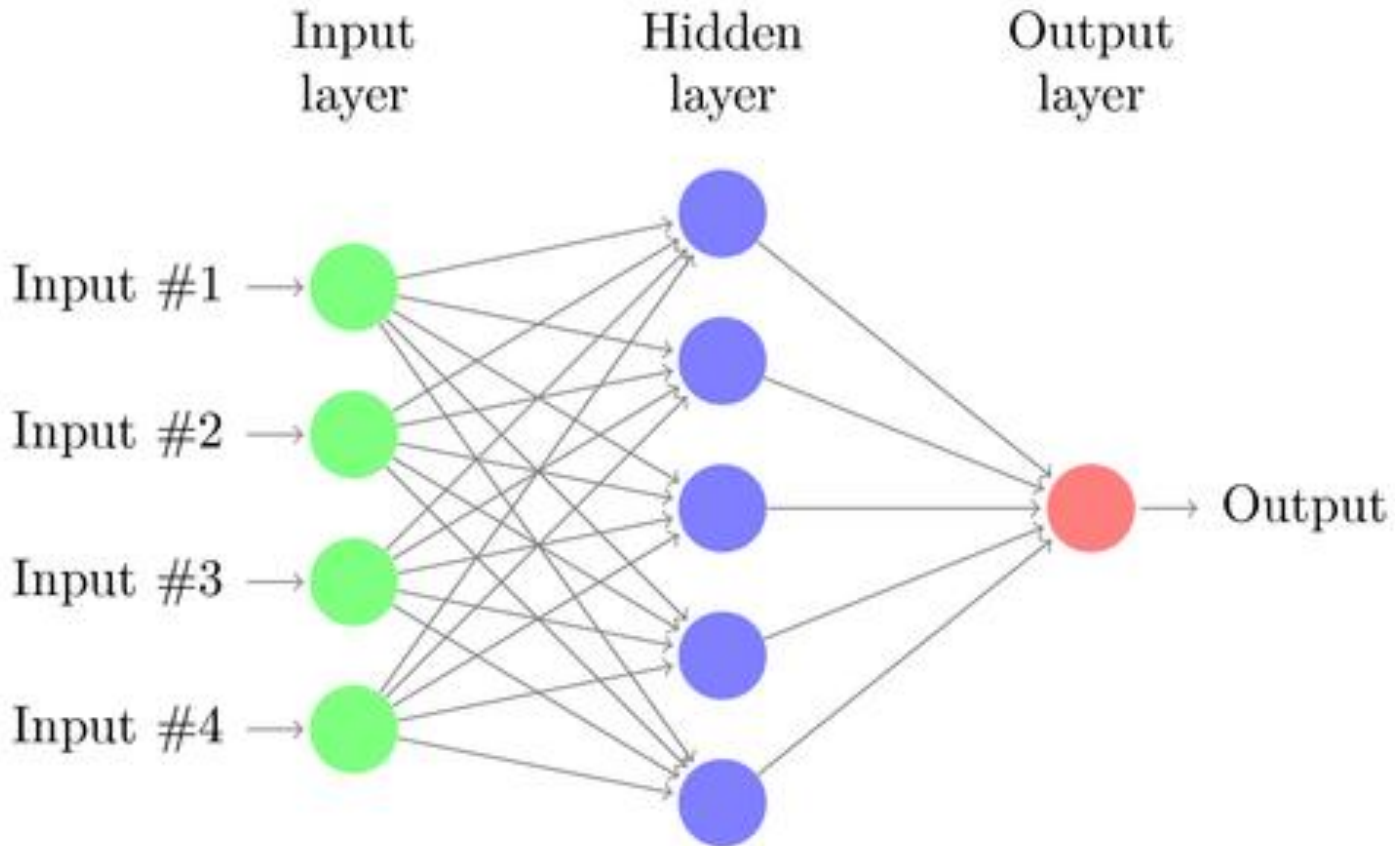
# How do we know that all these are chairs?



# Low level features of an object



# Artificial Neural Networks

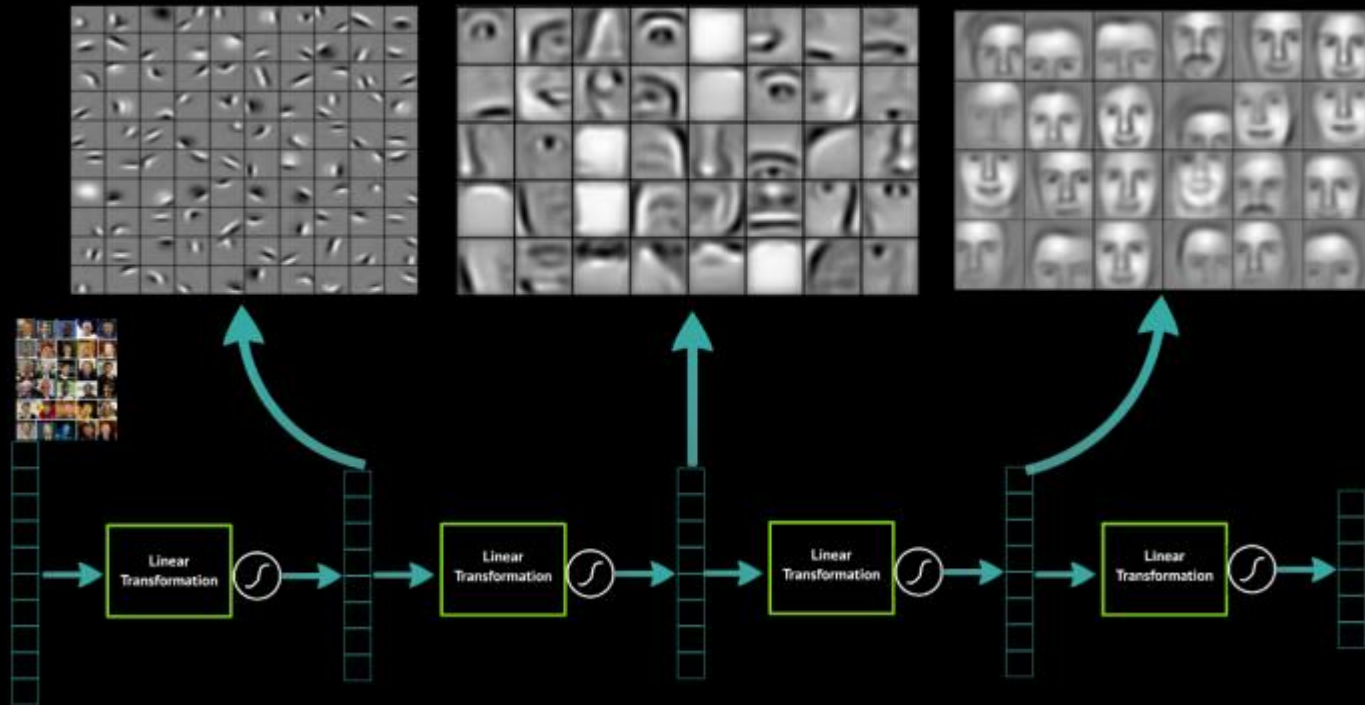




# GoogLeNet



# Deep Learning learns layers of features



# User interaction data analysis

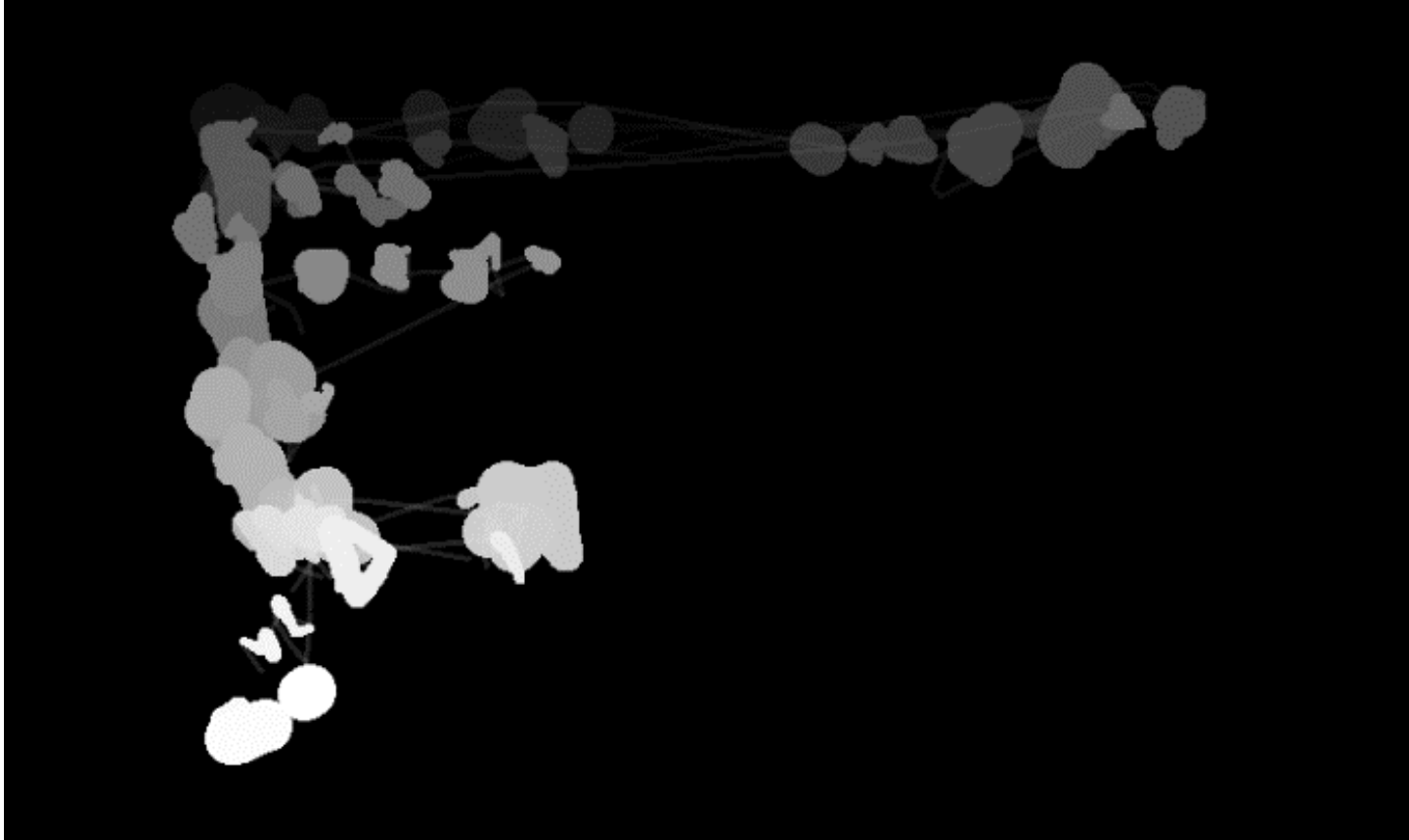
- gaze data – which features?
  - AOs, sequences
- how to evaluate gaze data of several users?
  - identify outliers - users or interaction segments
  - compare/cluster interactions data
- provide efficient representation to supervised learning algorithms
  - higher level features



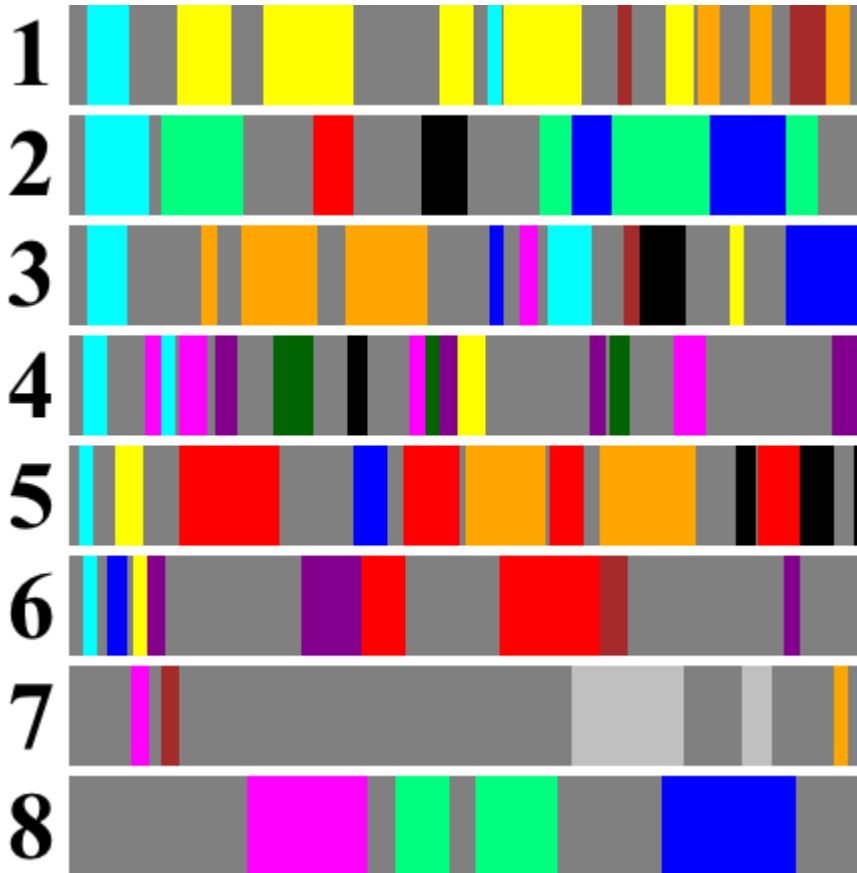
# Our approach

- Stochastic generative model
  - Restricted Boltzmann machine
  - Input: gaze data (sliding window)
  - Output: binary vector (dimension 200)
- Clustering of resulting binary vectors
  - Hamming distance

# Input to the network – a heatmap

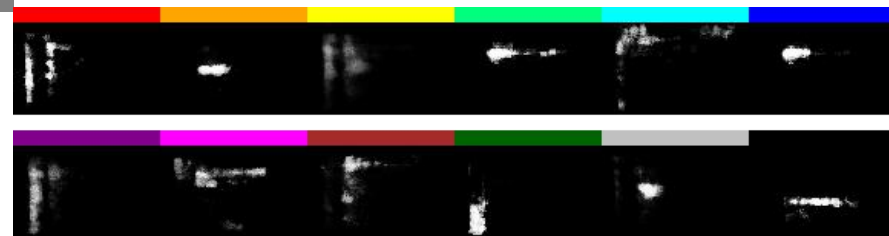


# Patterns of user interaction



8 participants

12 most frequent clusters



# User eXperience @ FIIT STU

## UX Lab



emotion  
detection



300 Hz  
Tobii eye-tracking

3D depth camera



EEG Emotiv

ECG, GSR, FSR, °C



## UX Class

20x



3D depth camera



60 Hz  
Tobii eye-tracking



emotion  
detection





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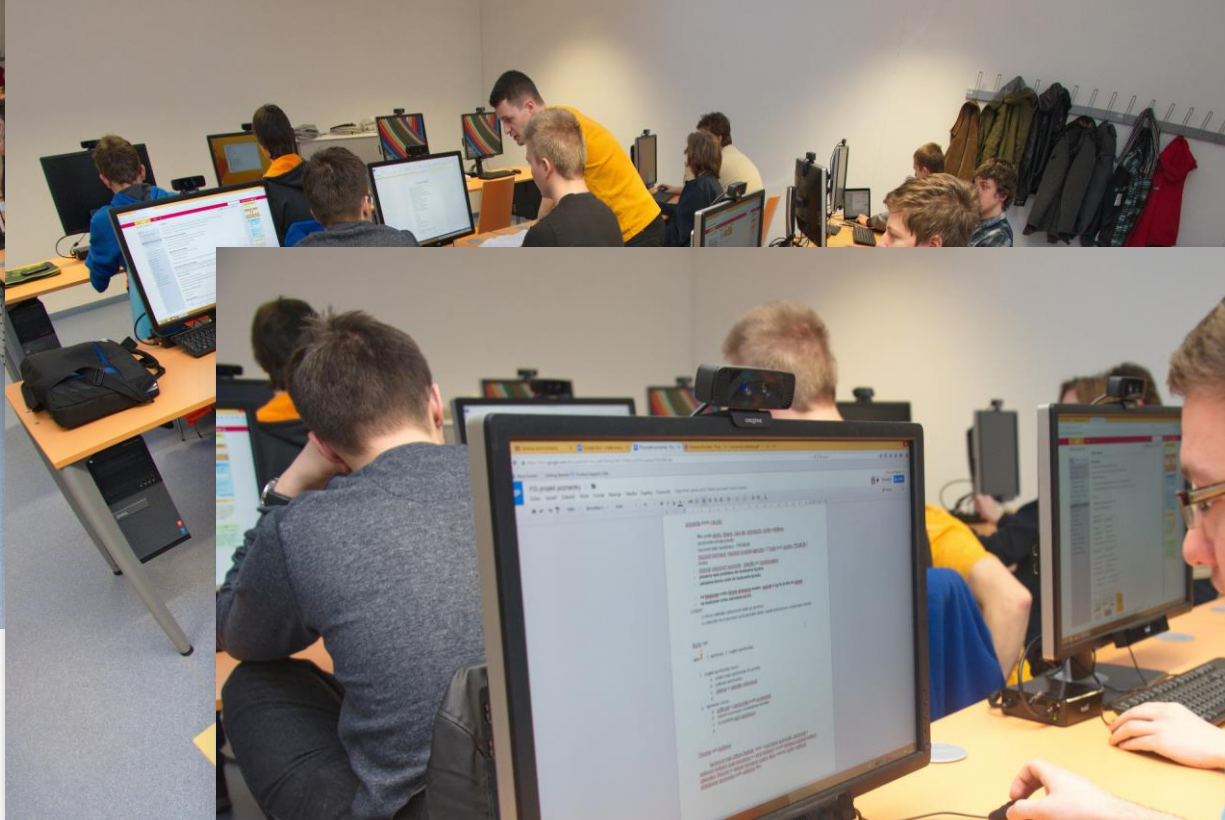




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# UX Lab

- Observing emotions on multiple levels:
  1. Sensors on the neuro-level (brain) (EEG)
  2. Sensors on the physiological level  
ECG, GSR, FSR, °C
  3. Visually, using software analysis of facial features from HD and depth camera streams



Happy,  
Sad,  
Angry,  
Surprised,  
Scared,  
Disgusted



Creative Senz3D



# UX Class

- Run experiment with 20 participants in parallel
  - stable conditions
- Computer class with technology of future
  - Support of learning using personalized web-based educational systems
- 20x PC with sensors (eye-gaze, cameras, ...)
  - Observing and adapting to the way how students work/use: keyboard, mouse, eye-gaze, emotions



Creative Sensz3D

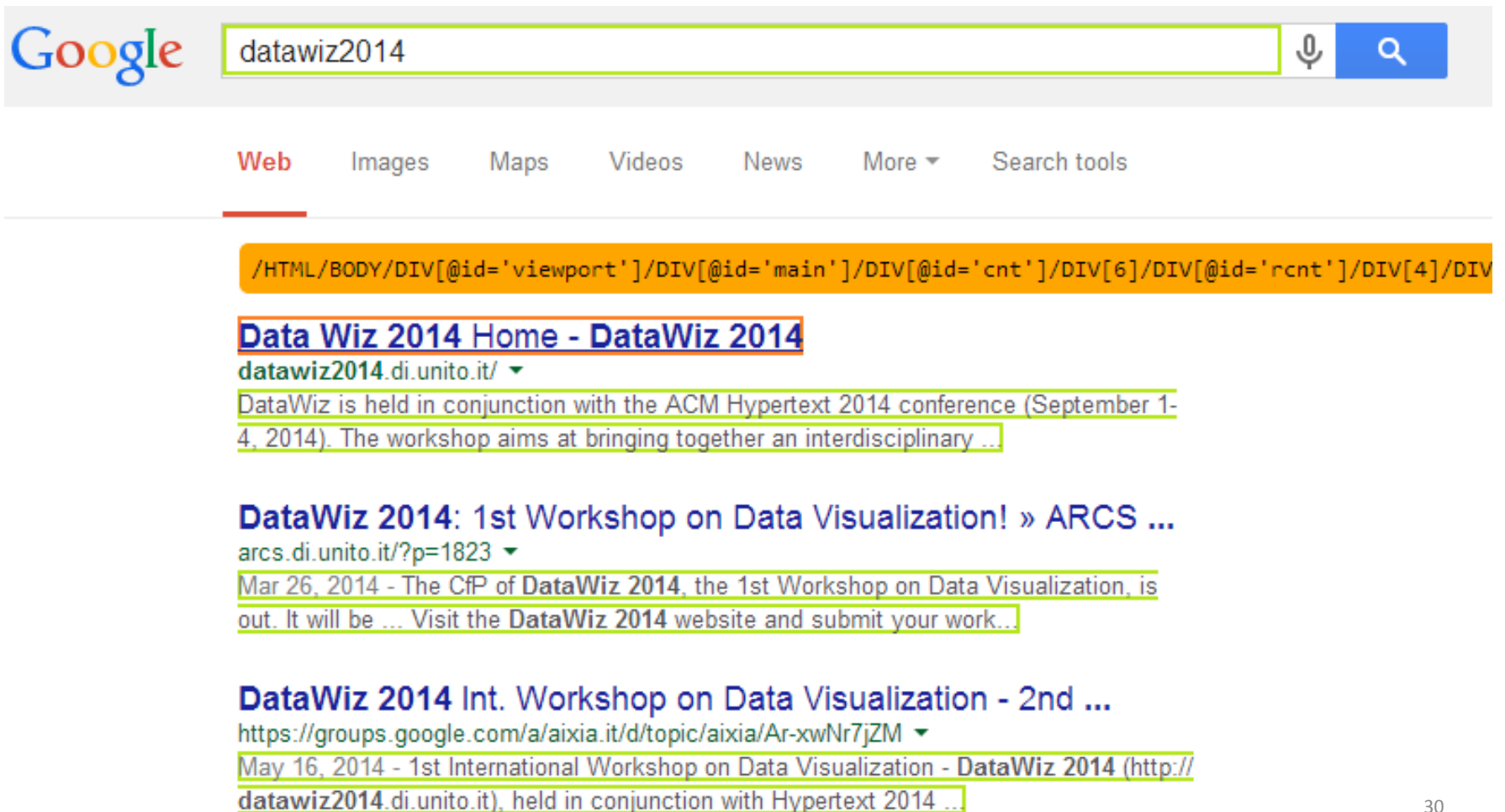


60 Hz  
Tobii eye-tracking



# Observation in dynamic web applications

## Specifying AOI (area-of-interest)



The image shows a Google search interface. The search bar contains the text "datawiz2014". Below the search bar, there are navigation links for "Web", "Images", "Maps", "Videos", "News", "More", and "Search tools". The search results are displayed below a horizontal line. The first result is titled "Data Wiz 2014 Home - DataWiz 2014" and includes the URL "datawiz2014.di.unito.it/". The second result is titled "DataWiz 2014: 1st Workshop on Data Visualization! » ARCS ..." and includes the URL "arcs.di.unito.it/?p=1823". The third result is titled "DataWiz 2014 Int. Workshop on Data Visualization - 2nd ..." and includes the URL "https://groups.google.com/a/aixia.it/d/topic/aixia/Ar-xwNr7jZM".

Google

datawiz2014

Web Images Maps Videos News More Search tools

/HTML/BODY/DIV[@id='viewport']/DIV[@id='main']/DIV[@id='cnt']/DIV[6]/DIV[@id='rcnt']/DIV[4]/DIV

**Data Wiz 2014 Home - DataWiz 2014**  
datawiz2014.di.unito.it/

DataWiz is held in conjunction with the ACM Hypertext 2014 conference (September 1-4, 2014). The workshop aims at bringing together an interdisciplinary ...

**DataWiz 2014: 1st Workshop on Data Visualization! » ARCS ...**  
arcs.di.unito.it/?p=1823

Mar 26, 2014 - The CfP of DataWiz 2014, the 1st Workshop on Data Visualization, is out. It will be ... Visit the DataWiz 2014 website and submit your work...

**DataWiz 2014 Int. Workshop on Data Visualization - 2nd ...**  
https://groups.google.com/a/aixia.it/d/topic/aixia/Ar-xwNr7jZM

May 16, 2014 - 1st International Workshop on Data Visualization - DataWiz 2014 (http://datawiz2014.di.unito.it), held in conjunction with Hypertext 2014 ...

# Our gaze-data related projects

- Analyzing User Gaze on the Web
  - which parts of a web page were really read
- Deception detection
  - web-based questionnaires
- Enhancing crowdsourcing precision by taking into account gaze data
  - which other options were considered

# Conclusions

- Unsupervised machine learning for modeling user interaction data (including gaze data)
  - get a higher-level representation of an interaction
  - build a prediction/classification on top of that
  - quickly filter-out interesting data
- Infrastructure
  - Detailed observations in UX lab
  - Parallel experiments in UX class

