Some Aspects of e-learning Systems

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Content

- Personalization and adaptation in e-learning systems
- System's architecture of Protus
  - Learning style identification in Protus
    - Eye-tracking in learning systems
      - Posibilities for eye-tracking integration in Protus
        - Conclusion

Personalization in E-Learning Systems

- Generally speaking, term "**Personalization**" means the process of deciding **what the highest value of an individual is if (s)he has a set of possible choices**.

- These choices can range from **a customized home page** "look and feel" to product recommendations or from banner advertisements to news content, **personalization in educational settings**.

Personalization in E-Learning Systems

- The topic of personalization is strictly related to the shift **from a teacher-centered** perspective of teaching **to a learner-centered**, competency-oriented one.
- **Two main approaches** to the personalization can be distinguished:
  - **user-profile based personalization** and
  - **rules-based personalization**.

Personalization and Personalized Learning

- Personalized e-learning offers to learner's **customization of a variety of the elements of the online education** process:
  - **The learning environment** - **content and its appearance** to the learner (like **backgrounds, themes, font sizes, colors**, and so on)
  - **The learning content itself** - multimedia representations (like **textual, graphical, audio, video**, and so on)
    - **The interaction** - **include** facilitator, **student and the learning content** (e.g. mouse, keyboard, tap/swipe; e.g. using Quizzes, Online discussions, "Gaming", Tutorials, Adaptive learning approaches)

Personalization and Personalized Learning

- **Numerous important aspects** should be taken into account when deciding **to personalize an e-learning environment:**
  - **Personalize the environment**—determine **how online e-learning environments should look like**.
    - **Personalize the content**—**incorporate content from the learners' personal environment** (reflect learners' browsing habits and preferences).
      - **Personalize the media**—according to their **learning styles and preferences some learners like to watch a short video or read a printed PDF files**.
        - **Personalizing learning sequences**—**nonlinear presentation of contents** allows learners to choose how they will learn.

Personalization and Personalized Learning

- **Personalize the roles using photographs and pictures**—use a photograph of the instructor to make the content more "personal."
- **Personalize the conversation**—use text or voice/video and adjust used sentences.
- **Personalize the navigation**—allow learners to explore various parts of the content.
- **Personalize the learner**—make the course personal to the learner.
- **Recognize individual competency**—skip known parts of teaching material and start learning the new topics.
- **Personalizing learning objectives**—enable learners to achieve better the learning objectives.

Personalization and Personalized Learning

- **Harmonization of mentioned aspects** will obtain a truly Personal Learning Environment (PLE) and **give learners the chance to learn:**
  - what they want
  - when they want, and
  - even to learn according to the **preferred method of learning**

Adaptation of E-Learning Systems

- In the last few decades "**Adaptation in E-learning**" has generated tremendous interest among researchers in computer-based education.
- As a consequence, two key terms appeared: **adaptivity** and **adaptability**.
- **Adaptivity** is such kind of behaviour where the **user triggers some actions in the system that guides the learning process**.
- **Adaptability** is such kind of behaviour where the **user makes changes and takes decisions on the learning process**, i.e. it is a possibility for **learners to personalize an e-learning lesson** by themselves.

Adaptation of E-Learning Systems

- **Adaptivity and adaptability are inseparable from personalized learning.**
- In order **to increase the performance of pre-defined criteria** (like economic, educational, user satisfaction-based or time-based) **instructor** must **configure a set of specific elements** (usually based on content, interface, order, time, assessment, and so on).
  - **Three essential inputs** exist in a balanced formula **for adaptation**: the **user** (learner, student), the **teacher** (tutor, instructor), and the **set of pre-defined rules** made by the learning instructor i.e. designer.

Adaptation of E-Learning Systems

- Usually, **three essential types of adaptation** have been proposed in **literature**:

1. **Interface-based** (also known as adaptive navigation).

It relates to elements and options of the interface and usability and adaptability (size, colour, etc.).

2. **Learning flow-based**. The **learning process is dynamically adapted to the sequence in appropriate ways the contents** of the course is delivered.

3. **Content-based**. In such systems **resources and activities dynamically change their actual content** (for example systems based on adaptive presentation).

Adaptation of E-Learning Systems

- Also, there are some key researchers in e-learning area who recognized and proposed several **additional kinds of adaptation:**

1. **Interactive problem solving support.** In order to get an appropriate solution to a problem the **learner is guided (from an online or offline tutor or from a predefined set of rules**) to the next step in the learning process.

2. **Adaptive information filtering.** In order to provide relevant and categorized outputs to the learner **system takes care of appropriate information retrieval**.

3. **Adaptive user grouping**. Such kind of systems **allows ad hoc creation of learners' groups and collaborative support** for performing particular tasks

Adaptation of E-Learning Systems

- Some authors proposed **further extension of the classification**:

  1. Adaptive evaluation. Based on the performance of the learner and the guidance of the tutor, elements like the actual content, **the evaluation model, and the running of a test can be changed**.

  2. Changes on-the-fly. In these systems there is the possibility to **adapt/modify a course on-the-fly** by the instructor in run-time.

Adaptation of E-Learning Systems

- **Adaptation and personalization are posing new research** and development **challenges** to modern e-learning systems.
- E-learning definitely becomes smarter empowered by adaptation and personalization.
- Recently advanced **Artificial Intelligence techniques** have been exploited **for implementation of smarter online** (but also blended learning) **scenarios**, including complex character of collaboration.

Adaptation of E-Learning Systems

- The most popular types of personalization in today's e-learning systems are:
- **Learning style identification.** Personalization of the system is based on the identified learning styles of each user of the system.
- **Recommendation systems.** These systems are used to **recommend appropriate educational material to the learner** and to **select optimal paths** through the Learning materials.
  - **Link adaptation.** The system **modifies the appearance and/or availability of every link** that appears on a course Web page, in order to **show the learner, whether the link leads to interesting new information**.

Adaptation of E-Learning Systems

- **Personalised pedagogical agents.** The demand of modern e-learning systems is to make **learning process more challenging, exciting and highly interactive**.
- Usually **e-learning environments are equipped with different kinds of agents** that support more intelligent and **human-like (teacher-to-student) communication** within the system.
- **Personal, pedagogical avatars** are a way to facilitate higher quality of delivering topics and assessing acquired knowledge.

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Protus

- PROgramming Tutoring System - provides learners with **personalised courses from various domains**.
- General tutoring system.
- It is an **interactive system**
  - allows **learners to use teaching material** prepared for appropriate courses,
  - includes parts for **testing acquired knowledge**.
  - Components that support **different recommendation techniques were integrated** in Protus in order to allow:
    - standardization and formalization of content and
    - enable the reuse and the interoperability of the system.

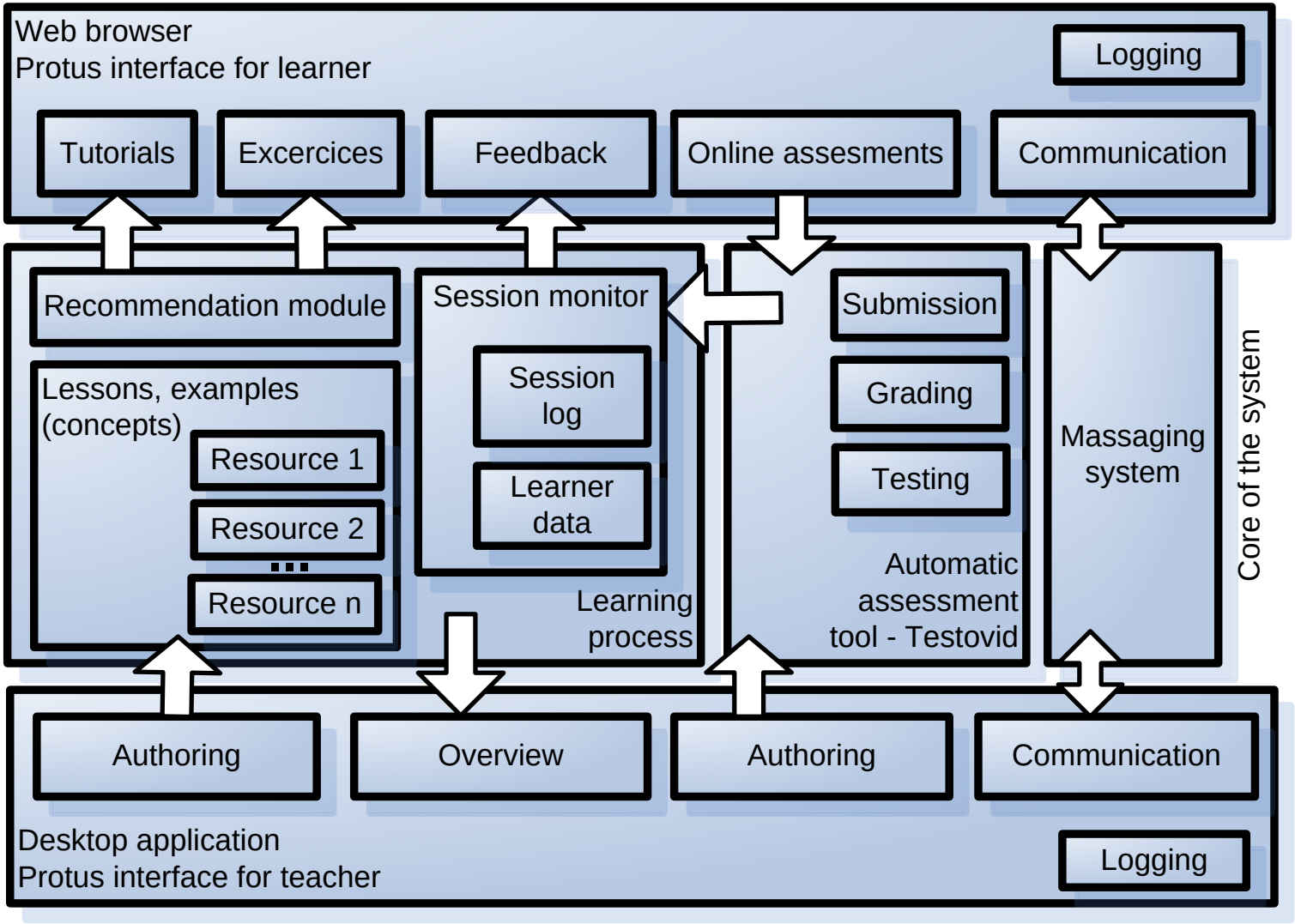
Protus

- T**he first completely implemented** and tested version of the system was for **introductory Java programming course.**
- The course is designed for learning programming basics for learners with no previous object-oriented programming experience.
  - Beneficial for **providing learners with personalized learning experience**.
  - Useful for **generating feedback for other key participants in the learning process** – content authors and teachers.

Protus's architecture

- Adaptable, expandable and separated components.
- The system **enables easy modification of adaptation options and personalization of learning materials** that are offered to learners.
- The system architecture of Protus enables the **development of courses in different domains** in three phases:
  - creation of skeleton application with use of Vaadin Java framework,
  - creation of individual courses, appropriate teaching materials for each course as well as a set of appropriate tests for assessment of acquired learners' knowledge,
  - presentation of personalized learning materials to each individual learner.

Protus's architecture



The recommendation component

- The **module for generating recommendations** of Protus is designed to:
  - **recognize the behaviour patterns of learners and identify their learning styles**,
  - **form clusters (categories) of similar learners**, based on their learning styles and
  - **categorize teaching materials based on their rating and present recommended learning materials to learners**.
- The main aim of Protus is:
  - to improve **adaptation of the teaching material** according to demand and need of each individual learner.
  - This version of the system supports personalization options in the form of **tag-based recommendations** systems.

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Learning style identification in Protus

- There are over seventy identifiable approaches to investigate and/or describe learning style preferences.
- We used one such data collection instrument, called **Index of Learning Styles – ILS by Felder and Soloman**
- **The ILS is a 44 questionaire, freely available, multiple-choice learning styles instrument**, which assesses variations in individual learning style preferences across four dimensions or domains.

Learning style identification in Protus

- Within each of the four domains there are two categories:
  - ***Information Processing***: Active and Reflective learners,
  - ***Information Perception***: Sensing and Intuitive learners,
  - ***Information Reception***: Visual and Verbal learners,
  - ***Information Understanding***: Sequential and Global learners.
- Before initial session, and after learning style has been determined by the ILS, current learning style category of the particular learner must be written in learner model of Protus
  - The learning style will be further investigated (and updated if necessary) by observing a pattern in the choices he/she makes.

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Introduction

- Eye-tracking technology - a set of methods and techniques used to:
  - discover,
  - identify and
  - record the activities of eye movements.

- Eye-tracking system confirmed its usefulness in terms of:
  - identifying behavioural response,
  - presenting cognitive load,
  - providing an alternative means for human-computer interaction,
  - prompting interface design and
  - adapting appearance of elements according to user data.

Introduction

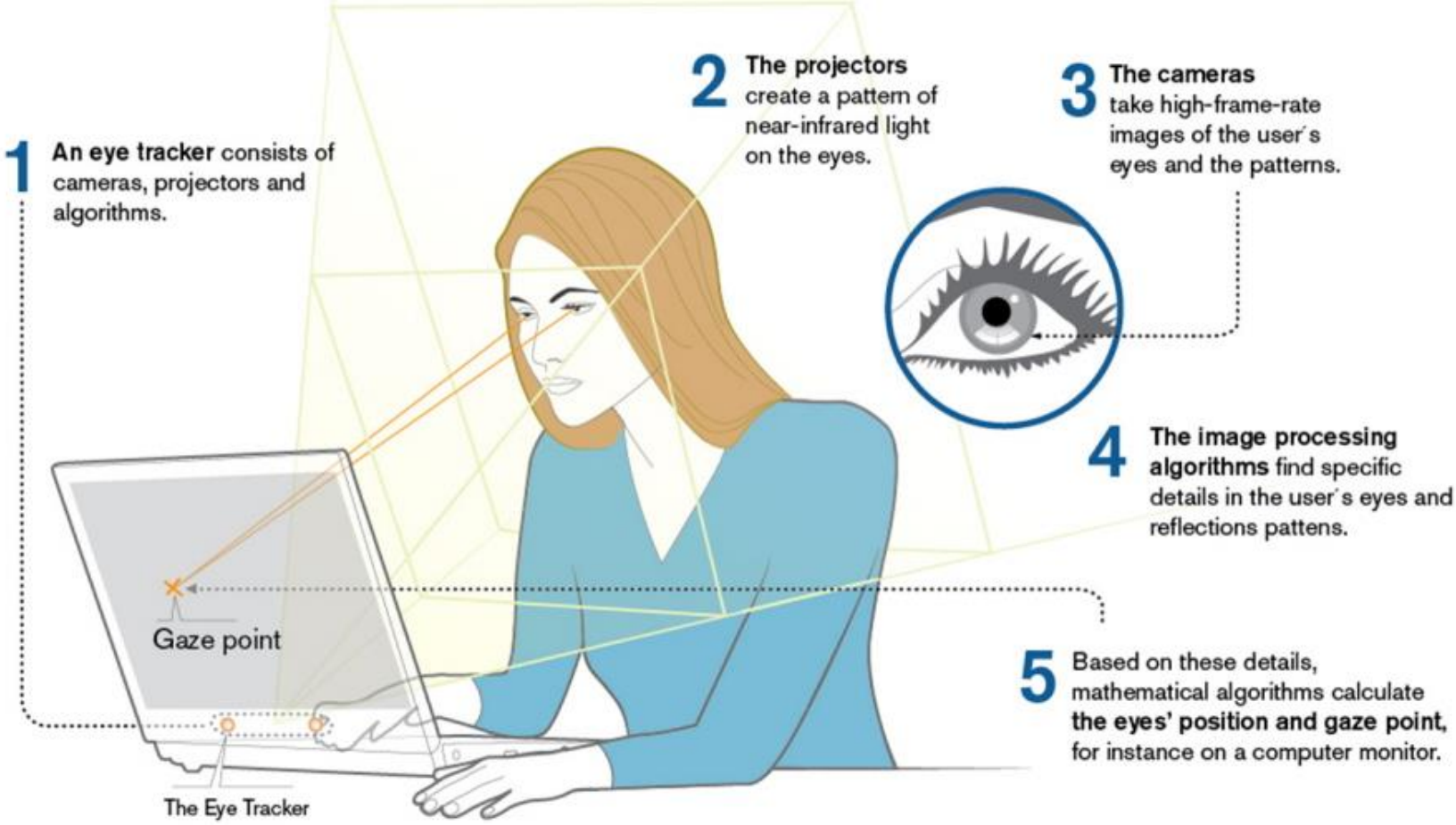
- **Incorporating eye tracking** into adaptive e-learning systems - **useful in a process of adaptation** to the requirements and needs of the learner.

- **Personalization of an e-learning system** based on the learner's cognitive load levels **calculated from eye-tracking data will bring:**

  – the advantage of **having a personal tutoring system into a wideband environment**, with

  – successful **training by increasing information transfer and maintenance**.

EYE-TRACKING TECHNOLOGIES



High performing eye-tracker system (http://www.tobii.com/group/about/this-is-eye-tracking/)

EYE TRACKING MEASUREMENTS

- ***Gaze (proportion of time) on each area of interest (AOI).*** This metric considers **gaze duration** and **frequency of gazing** on a display element.

- In order to reveal patterns describing how a user's attention is directed to a given visual area, it can be **useful to measure**:
  - the **duration of eye fixations**,
  - the **number of fixations**, and
  - the **amount of re-fixations** (i.e. fixating on an area or object multiple times).

EYE TRACKING MEASUREMENTS

- ***Fixation duration and saccade (***a rapid movement of the eye between fixation points***) length.*** These metrics **indicate difficulty of information extraction and reflect the importance of that area of the display**.
- **Fixations** have been successfully applied to **measure the level of image and problem complexity** and to identify the part of a screen viewed during instruction.
- Saccade length decreases when task complexity increases.
- In the field of **e-learning this might be useful during studying examples, solving tasks or code exercises** in the programming field.

EYE TRACKING MEASUREMENTS

- ***Total Number of fixations.***

- A **larger number of fixations specifies** less efficient search resulting from a **poor organization of display elements.**
- In **e-learning environments**, it is important to consider the **relationship between number of fixations and task solving time**.
  - For example, **more demanding tasks will require more fixations**.

EYE TRACKING MEASUREMENTS

- ***Number of fixations on each area of interest.***

- **More important elements will be fixated more frequently**.

- In e-learning environments, the percentage of fixations in an area of interest can serve as a simple indicator of the attention on an interface element or content region.

- We can **analyze the number of fixations on various elements** (text portions, graphics, diagrams, programming code, figures, etc.) **and make conclusions useful for the learning process**.

EYE TRACKING MEASUREMENTS

- ***Pupil response.*** In terms of **specifying a user's cognitive load**, pupil response, known as 'pupillometrics', has **gained important acceptance**.

- Pupillary responses - **can be used in a procedure of emotional stimulation**:
  - the size of the pupil is significantly larger after high initial stimulation than after neutral arousal – E.g pupil diameter is especially larger when "solving tasks" than when simply "reading".

  - Pupil size is also analysed with the aim to discovery the best moments when to interfere interactive tasks.

EYE TRACKING MEASUREMENTS

- ***Scan path (sequence of fixations).***

- Scan path and derived measures such as the transition probability between areas of learning sequences **can indicate the efficiency of the elements arrangement in the user interface.**

- If we know the sequence of fixation through the lessons and perform the assessment of the knowledge level the learner gained, we can improve the adaptability of an e-learning system.

EYE TRACKING RULES

- **The 'Fitts's law'** defines a rule according to the size of the displayed objects.

- **Visually emphasized objects get much attention over every other section on the page**.

High-quality lesson's pages - the elements that "pop" are those that are relevant, and content that do not encourage learners to take action should not be emphasized and prominent.

EYE TRACKING RULES

- **The Effect of Video material.**

- Videos - the most powerful in capturing eyeballs, even when they were not the first results.

- **Video results attracted more attention** than a regular search listing, especially when they were near the top of the page.

Placing appropriate video recordings in the form of tutorials at the top of the lesson's page could attract more attention of learners.

EYE TRACKING RULES

- **The Power of Directional Cues. Human beings have a natural tendency to follow the gaze of others.**

- Visual elements (graphical presentations, pictures and diagrams) are an important part of a website's overall design, but **most pages can be optimized by including images that serve as visual cues to indicate where visitors should look next.**

Being guided throw the learning material can be very useful - especially by taking as a reference behaviours that previously produced good results in terms of the level of learners' knowledge.

EYE TRACKING RULES

- **The F-Pattern.** F-pattern of reading is usual throughout the Web.
- **Users on the Web tend to browse sites based on their reading habits**.
- For English speaking people and **languages with similar reading patterns, the left side of the screen is deeply favoured in all articles, e-commerce sites or search engine results.**

In e-learning environments it would be useful to deploy the most important facts and definitions of the lessons according to the F-pattern.

EYE-TRACKING INTEGRATION IN E-LEARNING ENVIRONMENTS

- **Eye tracking in e-learning domain has been successfully used** for:
  - **implicit recognition of learner intention,**
  - **observing learners' multitasking activity,**
  - **enhancement of navigation and determining learning patterns** or decreasing learner attrition level.

These approaches expand the tracking of learners' actions, recognizing learners' face or gesticulations, which can specify learners' emotions or even mood.

EYE-TRACKING INTEGRATION IN E-LEARNING ENVIRONMENTS

- **AdeLE (Adaptive e-Learning with Eye tracking)** is noted as the **first and the most popular**, even though the project have been abandoned several years ago.

- The main objectives are **observing the behaviour of learners in learning processes in real time, by monitoring** characteristics such as:
  - **areas of interest,**
  - **time spent watching them,**
  - **frequency of visits and sequences or**
  - **patterns according to which content is studied.**

EYE-TRACKING INTEGRATION IN E-LEARNING ENVIRONMENTS

- **iDict** - **adaptive e-learning system** developed as an assistance **for translation in language courses**.
- iDict **tracks the learners' gaze path** while they are reading text written in a foreign language.
- When possible difficulties are noticed, during monitoring the reading process, **iDict shows tooltips with the translation of exact words or sentences**.

EYE-TRACKING INTEGRATION IN E-LEARNING ENVIRONMENTS

- **e5Learning (Enhanced Exploitation of Eyes for Effective E-learning)** - e-learning environment - allows the author of the course to set some **constraints** (e.g., **minimum time the learner would spend watching a certain part of content**).

- Functionalities for **simple emotion recognition** - recognize different states:
  - **'tiredness',**
  - **'high workload' or**
  - **'non-understanding'.**

- Allow learners to see what the system "thinks" about them.

EYE-TRACKING INTEGRATION IN E-LEARNING ENVIRONMENTS

- **Several studies - measure the cognitive load of learners while watching multimedia elements**, such as images, video and animations.

- The **way learners analyse science-related photographs in PowerPoint presentations** - classifying pictures into ‘illustrative’, ‘decorative’, ‘complementary’ and ‘explanatory’.

- **An image or animation with spoken text is more effective for learning than written text**.

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Posibilities for eye-tracking integration in PROTUS

- Observe users' learning behaviour in real time by **monitoring characteristics** such as:
  - **objects and areas of interest,**
  - **time spent on objects,**
  - **frequency of visits, and**
  - **sequences in which content is consumed.**
- Research could be focused on **analysing eye-movement patterns during learning and linking these patterns with cognitive processes**.

Posibilities for eye-tracking integration

- **Learner profile information of special interest** for system could be:
  - **personal characteristics, such as cognitive or learning styles**,
  - momentary states, like **tiredness or mental effort** as well as
  - other indicators during the learning process, such as **objects and areas of focus, time spent on objects, frequency of visits, and sequences in which learning content is consumed**.

Posibilities for eye-tracking integration

- **Course creators and administrators may use valuable information**
  - (e.g**. identified problematic areas of courseware sections**) without violating the privacy of individual learners.
- **The learning process will be improved**, because the **system will create or deliver adapted content by means of tracked statistical data** - optimise material to an individual's needs.
  - (e.g. by delivering more images/tables for learners that have problems with large and complicated texts).
  - **if somebody prefers text and ignores pictures the amount of pictures presented could be reduced, and vice versa**
  - **learning style theory – automatic identification of learning styles with the assistance of eye-tracker**

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Conclusions

- This system allows learners to:
  - ✓ take on-line course,
  - ✓ test their knowledge and programming skills,
  - ✓ submit their programming solutions,
  - ✓ get automated feedback,
  - ✓ get appropriate reports,
  - ✓ take on-line exams and be automatically assessed
  - ✓ realization of lectures and exercises on Java programming course

- Good posibilities for eye-tracking integration

Thank you