Knowledge Visualization in Biometric Face Recognition on Two-dimensional Images

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Abstract. *Biometric face recognition is one of the fields of computer vision. The part of biometric person identification has been extensivly researched. This resulted in a large number of algorithms used for person identification. This paper gives an overview and classification of those algorithms. Because of large number of algorithms, knowledge visualization is used for easier understanding of structure and connections between those algorithms.*

Keywords. knowledge, visualization, biometrics, face recognition, algorithms

1. Introduction

One of the goals of knowledge management is to make knowledge "visible" so that it could be easily accessed, discussed and managed[1]. For transfer of knowledge, some problems need to be solved[2]: the depth of information (balance between overview and details that need to be communicated), a limited time (limited time, attention and the capacity of the recipient), different backgrounds (different cognitive backgrounds and difficulties of decision-makers in understanding tools for visualization of knowledge), relevance (providing relevant information to various stakeholders).

The human brain is, most of the time, engaged in processing and analysis of visual elements. Which means that the images are processed before text, and require less energy for processing [2]. Several studies show that visual representations are superior in a variety of verbal tasks, such as illustrating the relationships, identifying patterns, as well as support for problem solving[3].

In this paper, introduction to the visualization of knowledge will be given, framework for visualization of knowledge will be displayed, and the difference between certain types of visualizations of knowledge such as heuristic sketches, conceptual diagrams, visual metaphors, etc, will be given. After that, a systematical review of biometric facial recognition will be given, and eventually, human knowledge gained by systematic review will be visualized.

2. Knowledge visualization

Field of knowledge visualization examines the use of visual representations in order to create and transfer knowledge between at least two people[1]. It is a sub-discipline of information design and design of education messages (pedagogy, didactics, educational psychology). The aim is to improve the visualization of knowledge transfer using computer and non-computer related visual content[4]. Examples of such visual formats are photographs, information graphics, diagrams, sketches, images, mental maps, interactive visualization, animation, imaginary visualizations... Visualization of knowledge involves not only the transfer of facts, but prefers the transfer of experiences, attitudes, values, expectations, perspectives, opinions and predictions, in a way that enables others to properly reconstruct and apply those experiences[1]. Some examples of knowledge visualization, such as heuristic sketches, conceptual diagrams, visual metaphors, animation skills, knowledge maps and structure of the domain will be described in this paper. All these types of knowledge visualization include not only the facts or numbers, but the principles and relationships that are used as an indirect form of knowledge communication that motivates the viewer to reconstruct the meaning[1].

While information visualization concentrates on the use of computer-supported tools to explore large amounts of abstract data,

visualization of knowledge focuses on the transfer of knowledge between people.

3. Knowledge visualization framework

To effectively create and transfer knowledge through visualization, it is necessary to consider at least three perspectives. These three perspectives provide answers to key questions related to the knowledge visualization[1]:

- What type of knowledge is visualized (object)?
- Why should this knowledge be visualized (purpose)?
- How this knowledge can be represented (method)?

Answers to these questions lead to a conceptual framework that provides an overview of the field of knowledge visualization. Perspective of types of knowledge that is visualized identifies the type of knowledge that is transferred. This framework distinguishes five types of knowledge[3]:

- Declarative knowledge (know-what)
- Procedural knowledge (know-how)
- Experiential knowledge (know-why)
- Orienteering knowledge (know-where)
- Knowledge of related people (know-who)

With the help of visualization purpose perspective, the reasons for using visual representations of knowledge are determined. Objectives to be expected are sharing knowledge through visual means, creation of knowledge, learning from the visual representation, visual representation of past experiences for future users or mapping knowledge to be easily identified by experts[1].

Methods perspective of knowledge representation structures visualization methods into six groups:

- Heuristic sketches
- Conceptual diagrams
- Visual Metaphors
- Animations of knowledge
- Maps of Knowledge
- Domain structure

4. Types of knowledge visualization

There are several types of knowledge visualization techniques. One of them is heuristic sketches. Heuristic sketches are drawings used to help a group of people in review and communication process. They make knowledge explicit and arguable. Sketch is defined as a rough drawing or painting in which the author marks his/her preliminary ideas for the work which will be executed with greater precision and detail. Main advantages of heuristic sketches are[1]:

- Representation of main ideas and key characteristics of a preliminary study
- Diverse and affordable
- Fast and can help to rapidly visualize concepts that appear
- Usage of pencil and paper draws attention
- Provide space for individual interpretation and encourage creativity in the group

Another form of knowledge visualization are conceptual diagrams.

They are defined as schematic views of abstract ideas using standardized forms. Conceptual diagrams are used to structure information and illustrate relationships. For transfer and creation of knowledge, conceptual diagrams help in making abstract concepts become more accessible, reduce the complexity of the key issues, expand knowledge and help in the discussion of the connections[6].

Next type of knowledge visualization are visual metaphors. Metaphor provides a way of understanding something similar to understanding something completely new, by transferring elements of understanding in the new domain. Metaphor provides quick information, it is very instructive and facilitates the learning process, metaphors may also improve remembering and coordination in groups. Visual metaphors used in the transfer or creation of knowledge may be natural objects or phenomena, or artificial (man-made) objects, actions, or concepts. Their main characteristic is to organize knowledge meaningfully and thus fulfill two functions. Position information graphically to keep them organized and structured, and convey an implicit insight about the information presented through the key features of used metaphor[6].

Animation of knowledge is computer-supported interactive visualization which allows users to control, communicate and manipulate different types of information in a manner that encourages the creation and transfer of knowledge. By knowledge interaction, new insights are created or shared, helping to focus so as to allow interactive collaboration, illustrate,

explore and discuss complex issues in different context[1].

Knowledge Maps are graphical formats that follow cartographic conventions for the purpose of review of the relevant knowledge. Knowledge Maps usually have two parts: a lower layer that represents the context for mapping and individual elements that are mapped within this context. The bottom layer (ground layer) usually consists of shared context that is understood by everyone (business model, product, geographic map). The elements that are mapped to this shared context range from experts and the community to the explicit and coded forms of knowledge such as articles, patents or expert systems[6].

Domain knowledge visualization is focused on identifying and visual representation of the dynamics of scientific frontiers in a multidisciplinary context and allows for new ways to visualize the sources of knowledge by visualization of links and structure of scientific domain[6].

This paper will use the conceptual diagram of Mind Map to visualize knowledge in the field of biometric facial recognition.

5. Biometric face recognition – A systematic review

The problem of face recognition can be defined as follows: If there is a set of facial images associated with the identity of the person (learning set) and the unlabeled set of face images of the same group of people (test set), it is possible to discover the identity of each person from test set[5]. Many algorithms have been developed to solve this problem. This article will give a systematic overview of the algorithms used for biometric face recognition.

The first step of a systematic literature review is to define a research question:

Which algorithms are used for biometric facial recognition?

Keywords to which search will be conducted are: face recognition, methods, neural networks, elastic bunch graph matching, principal component analysis, linear discriminant analysis, Gabor wavelets, support vector machines. Databases in which search will be conducted are the IEEE Xplore database, Science Direct and Google Scholar. A search found a large number of papers. Some of these papers were eliminated because of the lack of connection to the research question. After the elimination, 228 papers remained. Part of those papers is shown in Table 1.

Table 1. List of obtained papers

No.	Paper
1	M. Kirby, L. Sirovich, Application of the Karhunen-Loeve Procedure for the Characterization of Human Faces, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 12, No. 1, 1990, pp. 103-108
2	Turk, M.A.; Pentland, A.P.; Face recognition using eigenfaces, Computer Vision and Pattern Recognition, 1991. Proceedings CVPR '91., IEEE Computer Society Conference on, 3-6 Jun 1991, Cited by : 309
3	Manjunath, B.S.; Chellappa, R.; von der Malsburg, C.; A feature based approach to face recognition,Computer Vision and Pattern Recognition, 1992. Proceedings CVPR '92., 1992 IEEE Computer Society Conference on,Issue Date: 15-18 Jun 1992,Cited by : 11
4	Gordon, G.G.; Face recognition based on depth and curvature features, Computer Vision and Pattern Recognition, 1992. Proceedings CVPR '92., 1992 IEEE Computer Society Conference on,Issue Date: 15-18 Jun 1992,Cited by : 10
5	Kurita, T.; Otsu, N.; Sato, T.; A face recognition method using higher order local autocorrelation and multivariate analysis, Pattern Recognition, 1992. Vol.II. Conference B: Pattern Recognition Methodology and Systems, Proceedings., 11th IAPR International Conference on,Issue Date: 30 Aug-3 Sep 1992,Cited by : 5
6	Brunelli, R.,Poggio, T.:Face recognition through geometrical features,Lecture Notes in Computer Science,1992
7	Brunelli, R.; Poggio, T.; Face recognition: features versus templates,Pattern Analysis and Machine Intelligence, IEEE Transactions on,Oct 1993,Volume: 15 Issue:10,Cited by : 197
8	Pentland, A.; Moghaddam, B.; Starner, T.;View-based and modular eigenspaces for face recognition, Computer Vision and Pattern Recognition, 1994. Proceedings CVPR '94., 1994 IEEE Computer Society Conference on, 21-23 Jun 1994,Cited by : 112
9	Cox, I.J.; Ghosn, J.; Yianilos, P.N.; Feature-based face recognition using mixture-distance, Computer Vision and Pattern Recognition, 1996. Proceedings CVPR '96, 1996 IEEE Computer Society Conference on,Issue Date: 18-20 Jun 1996,Cited by : 10
10	Goudail, F.; Lange, E.; Iwamoto, T.; Kyuma, K.; Otsu, N.; Face recognition system using local autocorrelations and multiscale integration, Pattern Analysis and Machine Intelligence, IEEE Transactions on,Issue Date: Oct 1996,Volume: 18 Issue:10,Cited by : 21

Since the area of interest is biometric facial recognition on two-dimensional images, papers were initially divided into facial recognition on photos and videos. Next step was to further

divide them on facial recognition on two-dimensional and three-dimensional images. This left us with 19 papers related to video-based face recognition, 30 papers on three-dimensional face recognition, and 179 papers on two-dimensional face recognition.

Based on this division, a review of articles by year of publication was made (Fig.1, Fig.2, Fig.3).

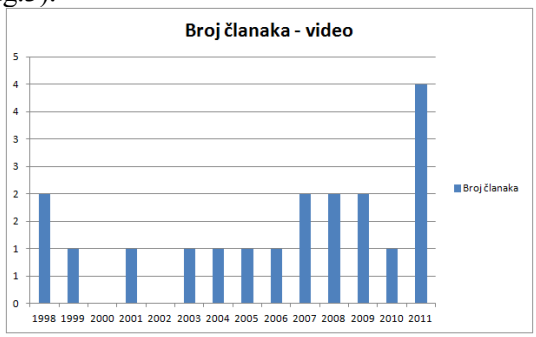

Figure 1. Papers by year in video-based face recognition

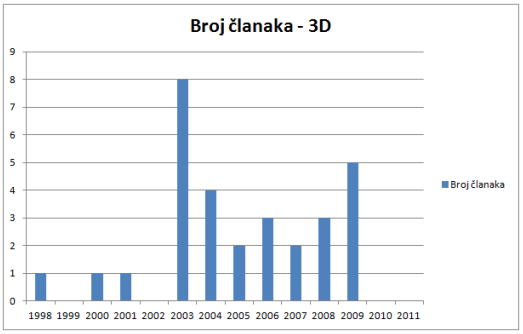

Figure 2. Papers by year in three-dimensional face recognition

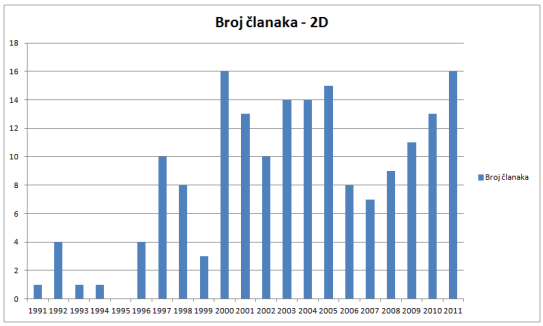

Figure 3. Papers by year in two-dimensional face recognition

Graphs show that the majority of research on the subject of biometric face recognition has been published from year 2000. to date.

The next step was the identification of the most commonly used algorithms for biometric facial recognition on two-dimensional images. These algorithms include: Principal components analysis (PCA), Independent component analysis (ICA), Linear discriminant analysis (LDA), Elastic bunch graph matching (EBGM), Support vector machine (SVM), wavelet based, Gabor Jets based, Fourier transform based, Discrete Cosine Transform (DCT), Linear binary patterns (LBP), Laplacianfaces (LPP), Active Appearance model (AAM), Hidden Markov model (HMM), Bayesian probability based and neural networks based.

For clarity, these algorithms are grouped into three major groups based on their basis: methods based on mathematics, methods based on statistics and methods based on neural networks (Fig. 4).

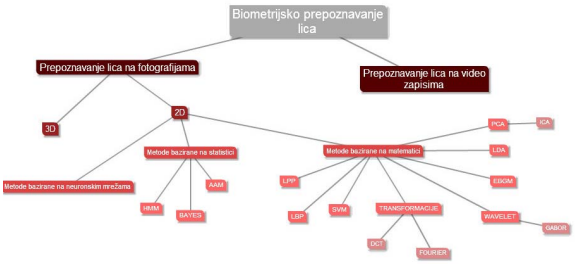

Figure 4. Mind map of algorithms for biometric facial recognition

6. Difference between knowledge visualization and information visualization

Related field and a precursor of knowledge visualization is visualization of information. Visualization of information offers new visual applications for interactive viewing and analysis of data to get new insights to the observed trends or clusters. Information visualization is defined as the use of computer-assisted, interactive representations of abstract data to expand knowledge. The field of information visualization ignores the potential of visualization as a medium for the transfer of complex knowledge. Also, visualization of information ignores the integration of visualization methods not based on a computer (posters, physical objects) such as used by architects, artists and designers. This is the goal of knowledge and also the main difference between knowledge visualization and information visualization. Information visualization aims to study large amounts of abstract data (often numerical) to get a new insight or information that would be more affordable. In contrast, visualization of knowledge transfers and facilitates the creation of knowledge between people in a way to give

them a richer way to express what they already know[1].

7. Conclusion and future research

Visualization of knowledge offers solutions for the transfer and creation of knowledge, and emphasizes the important and often overlooked potential that researchers can take advantage of knowledge management: our innate ability to effectively process visual representation. Visualization of Knowledge also provides new ways of development for the visualization of information, because it expands that field in relation to other types of knowledge and other processes besides information research, because it uses information visualization methods based on computer as well as those that are not based on a computer. Future research will concentrate on usage of different aspects of knowledge visualization with a goal to help better understand complex fields of computer vision, especially face recognition and palm print recognition.

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