From prosopagnosia to image processing: feature enhancement module

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Abstract: - Prosopagnosia is a term coming from Greeks words “prosop” (face) and “agnosia” (inability/ impossibility to recognize or to identify it), also known as “face blind” affection. It might be present in different proportions in not so rare persons as it was previously believed. Extreme anomalies and abnormalities give important clues on how our brain is really functioning, our mind being able to reveal its secrets. “Understanding” a scene is not as simple as it seems to us even the interpretation that a little child might give to the things perceived around him. Yet, behind that little child there are months, years of knowledge acquisition. Cognitive aspects implemented in computational processes establish frames to model human actions relative to the human corresponding senses. The anatomical aspects, physiology, are modeled in simplified schemas in order to be implemented in virtual systems and machine models. Eye tracking models are examples to be considered for implementing artificial vision on robots. The paper comments, from the cognitive viewpoint, relevant recent studies on prosopagnosia, analysis the relevant features that have to be modularly treated in a face recognition system and proposes a new method of important directions detection on a face, which might constitute a new module, in addition to the existent face recognition software programs.

Key-Words: - Image processing, Dual Tree Complex Wavelet Transforms, Entropy, Prosopagnosia.

1 Introduction

The issues of knowing and modeling the way the human senses are functioning have always preoccupied scientists. Human vision occupies a central position from anatomical, cognitive, neuroscience point of view.
Prosopagnosia is a term that has been proposed by Bodamer (1947) [1] and was described for the first time by Wigan in 1844, and then Quaglino & Borelli in 1867 (paper translated by Ellis & Florence, 1990)”[2].
It defines a disorder of visual recognition of faces, which is sometimes genetically inherited or is caused by brain damages after accidents, trauma, strokes or chemical exposures. Stating this we are relying on the researches of Laura Schmalzl who identified among the first researches some interesting cases of congenital prosopagnosia, in Australia at Macquarie Centre for Cognitive Science [2], [3]. New research centers and teams are concentrating on studying this disease as Prosopagnosia Research Centre in London, in Belgium, Laboratoire de Neurophysiologie (NEFY), Université Catholique de Louvain [2], at Harvard [4], etc.
For these subjects, the difficulty is in recognizing faces even from their own families, and in memorizing new faces characteristics.
Researchers try to answer to the question if there is any possible connection or similarity between prosopagnosia and other objects recognition impairments [3]. This impairment is not due to sensory visual defects, neither to the intellectual, persons still being recognized by their voices or body shapes [5]. “Face images” are seen by these persons, but they are not evaluated [5]:
“People with face blindness often are unaware they have it” … “they just know nothing else to compare their perception to”. Those who acquire it, do not recognize any faces, at all, due to the injuries affecting the neurologic support of the face recognition function, situated in the right hemisphere, temporal lobe, fusiform gyrus area. Maybe young children that inherited face blindness

impairment develop adjacent brain areas that are able to support the recognition of other features instead of the face (in fact normal people are focusing on face, eyes, expression, usually neglecting movement particularities, body shapes, behavior, that are very important clues for them). We are recognizing photos that are presented right side up but often we have difficulties in recognizing them upside down. Strange enough, “face blind” people often recognize them better upside down as if it would be a reversed circuit or the information is treated by a different brain structure [5]. Monkeys are well perceiving face photos in both positions, maybe because they are better trained for this. Associated with prosopagnosia there are often detectable hearing distortions, hearing impairments (central auditory processing disorder) Asperger's syndrome or "topographic agnosia," (the difficulty to localize in space), lower hormonal activity, lower body temperature, etc. The researchers detected a “place processor” near the “face processor”. The human brain has areas that constitute “modules” in information processing. There is a similar “place blindness” that explains the topographic agnosia existence. Often, face and place agnosia run together, brain regions being situated in proximity. In a study on a random population made in 2006, almost 2% were “face blind” people, and among them 19% genetically inherited their impairment [5]. People with this impairment often have other abilities better developed (they perceive better the traits of movements, or are more attentive to other characteristics of the body – hands, shoulders, stature, depth perception). Some of them are seeing everything flat. Colors are also differently perceived, and we know now that, rarely, quite tetrachromat persons exist (seeing ultraviolet rays) while others might be Daltonist or even “color blind” individuals.

Emotions are also very differently understood, sometimes depending on gender differences. Therefore we are endowed with different visual abilities, changing with age [18], and we have “neuronal modules” specialized by long time training on very different aspects of our vision. More categories of traits are used by face blind persons, addressing different senses in accordance with their abilities: (a) on the body, beard and hair presence and shape, eye brushes, eyelashes forms, shapes of different parts of the body – hands, shoulders, etc; but, if hair cut changes, the problem become complicated even in recognizing someone very closed; (b) voice, emotions, accents, dialects; (c) gait, body particular movements and stereotypes. The abilities are so different that some people might see three dimensional depth while others detect manniersm, or are very attentive to clothing movements and shaping [5].

2 Towards an artificial vision system in support of prosopagnosia impairment

An artificial structure meant to well recognize faces is parallel implementing these different aspects and a weighted decision system is meant to centralize them, in order to detect and recognize faces. Such a structure is proposed here, in accordance with the physiological aspects of our vision.

In order to model human face recognition and to conceive a tool to help face blind people to exercise this type of cognition, we studied again what in fact the human gaze is searching on a new face? We compare more photos and we focus on the preponderant characteristics to which an expert system has to respond by well formulated rules.

Studies on eye movements for computer science purpose and physiologists’ studies, stated that we concentrate on new, unusual characteristics that we perceive in front of us. Face blind people usually do not recognize public persons as well as acquaintance faces.

In a system that might help prosopagnosia persons types of rules have to be extracted and these prosopagnosia persons have to be made aware of a lot of details in order to improve their skills. Face images obviously have different characteristics, when looked into details. We learned these images “by heart”, in fact by “pattern matching” acquired over time, without distributing their characteristics on categories.

When we try to analyze, we are looking for preponderant, important, impressing facial features. The eyes, the different gaze of acquainted persons are very characteristic for their personalities. Shape and preeminence of the forehead, shape and dimensions of their chin, are other characteristics to be taken into account when a “face blind” is learning to recognize, by peculiar particularities face photos, are formulated in rules.

A dedicated expert system to assist training for impaired persons has to have a module with semi-supervised recognition in order to be able to assist the recognition of new persons. A cell phone with this software implemented, that might “tell” the prosopagnosia impaired person the possible name of the person in front of it, may be useful to old persons as well, assisting them in training to remember persons’ images and names.

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3 A new module for face recognition

Numerous software programs have been emerged in the last decades, a lot of them being freely available on the Internet together with free databases [6] (for example Open CV [7]). The problem is not trivial and it is only partially solved [8], therefore we may well identify identical photos that are on the Internet, but identifying blurred, transformed face images, with peculiar expressions is a more complicated issue [9], [10].

There is already an interest in using wavelet transforms in face recognition [11]. We propose a method that uses texture detection on small areas in order to better identify the similarity of a new image with the image that we have in the database.

This method is using entropy and Dual Tree Complex Wavelet Transform (DTCWT) coefficients on square areas. These coefficients are able to detect orientation on more spatial directions: +15˚, +45˚, +75˚, -75˚, -45˚, -15 [12]. We divide the image in an even number of squares on each dimension, and we compute "wentropy" [13] on each of it.

A big value of entropy means a lot of "turbulences" steep transitions from bright to dark, in the local image, therefore "a lot of movements, high disorder" as we used to learn in physics.

A small value of the entropy means "calm zones", order, areas where there aren't a lot of "events" on the image.

We focus on the zones with high entropy. "Wentropies" calculated on grayscale in Matlab on a set of images, gave very low values on the blurred, almost uniform, areas and higher values on those which are wearing the important characteristics of the face.

DTCWT (explained in [12]) are computed on the selected squares and a threshold is fixed. Higher values than the fixed threshold highlight the preponderant directions.

The entropy E is an additive cost function such that $E(0) = 0$ and

$$E(s) = \sum_i E(s_i) \tag{1}$$

`It is computed using the formula of the "log energy".

$$E_l(s_i) = \log(s_i^2) \tag{2}$$

Therefore

$$E_l(s) = \sum_i \log(s_i^2) \tag{3}$$

with the convention $log(0) = 0$.

TABLE I - DTCWT PREPONDERANT COEFFICIENTS FOR THE CORRESPONDING SQUARES OF THE FACE IMAGE, FOR EACH OF THE SIX DIRECTIONS TAKEN INTO ACCOUNT

Square	+15˚	+45˚	+75˚	-75˚,	- 45˚,	-15
S22	0.1636	0.1228	0.1249	0.1155	**0.2208**	0.1524
S23	0.1921	**0.2642**	0.1417	0.1219	0.0653	0.0849
S24	0.0653	**0.2848**	0.0993	0.0572	0.0643	0.0852
S25	0.0984	**0.2775**	0.0942	0.0748	0.0721	0.0947
S32	0.1321	**0.3724**	0.2456	0.2218	0.1737	0.1925
S33	**0.2913**	0.1531	0.1442	0.1818	0.2213	0.1812
S34	0.1161	0.1273	0.1531	**0.2751**	0.1023	0.1054
S35	0.1371	0.1304	0.1206	0.1248	**0.2530**	0.1249
S42	0.1231	0.1517	0.1492	**0.2328**	0.1855	0.1132
S43	0.1864	**0.1920**	0.1559	0.1634	0.1035	0.1813
S44	**0.2817**	0.1413	0.2185	0.1975	0.1160	0.1524
S45	0.1621	0.1451	0.1719	0.1634	**0.2425**	0.1753
S52	0.1421	0.1315	0.2396	**0.2694**	0.1390	0.1183
S53	0.1115	0.1157	0.2258	0.2235	**0.2512**	0.1772
S54	0.1281	0.1689	0.1163	0.1691	0.1386	0.1203
S55	0.1743	0.1764	**0.3499**	0.1482	0.1792	0.1744

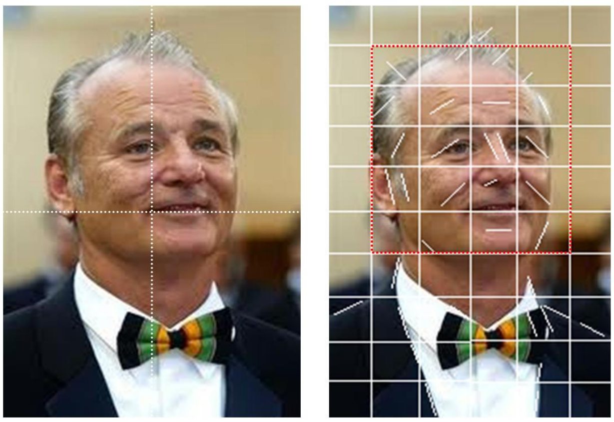

Fig. 1. Squared areas and the preponderant directions detected by DTCWT

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For the red square in Fig. 1, containing more relevant face features we have the following DTCWT coefficients on the six directions that are commonly chosen - Table I - where we observe the preponderant direction in a selected square, with higher values.

In order to learn more from prosopagnosia when programming a software for face recognition, we have "to keep it modular".

Even if a child "just learn to recognize his mother", studies made by using magnetic resonance imaging [14] stated that we have different areas for different aspects of our view: one area is responsible for face evaluation, another area is responsible for environment evaluation with different locations on brain hemispheres.

Color and texture, are also separately evaluated.

For detecting a line moving, fMRI detected around 20 areas activated on cortex.

We have modules for everything and the evaluation is parallel.

Eye has saccades that permit to sweep the image in front of us and to attribute each task to its specialized neuronal module.

In order to have a high performance specialized face recognition system, we have to evaluate separately each different aspect (color, texture, preponderant directions, proportions between the well known important points on the figure, etc).

The need of modularity and rule based systems, rules that might be extracted automatically, using the existent free face image databases, is obvious [15].

Face features analysis is possible to be done by detecting the area with higher energy and entropy and to analyses the preponderant directions by using DTCWT coefficient that have the advantage of well supporting rotational transformations [12], [16], [17].

This is one module in a more complex face recognition system. A complex system using it together with the classical systems helps prosopagnosia patients in training and learning face features for the impaired persons.

Conclusions and further work

Prosopagnosia is a disease which is difficult to recognize for a person born like this and more difficult to share it with the persons around (colleagues, office, boss, hierarchical structures). The research reveals interesting details on face recognition discovered in the last two decades, a lot of them due to web-communications, this being a result of uncontestable favorable influence of Internet on the recognition, study, and help for the study of a difficult identifiable impairment.

A large community has formed around this subject on Internet and scientists are now capable to help by specialized programs of training.

We are often trying to complete vision models emerged in the last decades with aspects driven from eye physiology, and this is the case in our paper. With the development of new software tools and the possibility to apply sophisticated mathematical theories, recognition programs become more diversified.

DTCWT has interesting particular applications, being able to detect preponderant directions in squared small areas on a face image, making a pattern matching with learned rules. This module is meant to complete the existent software programs with an additional feature, in order to raise the recognition percentages of the face images.

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