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Standardization in IRIS Diagnosis

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Abstract—Molecular image-based techniques are widely used in medicine to detect specific diseases. The analysis of the eye plays an important role in order to detect specific diseases. Eye background analysis is used in order to detect certain forms of diabetes and others diseases. In the alternative medicine plays the diagnosis of the iris an important role. One understands by iris diagnosis (Iridology) the investigation and analysis of the colored part of the eye, the iris, to discover factors which play an important role for the prevention and treatment of illnesses, but also for the preservation of an optimum health. Although alternative practitioner describe substantial success with the iris diagnosis. The conventional medicine is not convinced of the diagnosis method. A big drawback of the method is the subjective interpretation of what is seen in the iris image. An automatic system would pave the way for much wider use of the iris diagnosis for the diagnosis of illnesses and for the purpose of individual health protection. With this paper we de-scribe our work towards an automatic iris diagnosis system. We describe the image acquisition and the problems with it. Different ways of image acquisition and image preprocessing are explained. We describe the image analysis method for the detection of the iris. This method is based on our novel case-based object recognition and case mining method. Results for the recognition of the iris are given. We describe how to detect the pupil and not wanted lamp spots. We explain how to recognize orange blue spots in the iris and match them against the topological map of the iris. Finally, we give an outlook for further work.

Keywords—Iris diagnosis, Iris Image Acquistion, Iris Recognition, Pupil Recognition, Colored Spot Recognition, Standardization, Case-Based Object Matching, Topological Matching

I. INTRODUCTION

The iris of a human is not only relevant for biometry; it is also relevant for the prediction and diagnosis of the health of a human. The latter is called iris diagnosis. One understands by iris diagnosis (Iridology) the investigation and analysis of the colored part of the eye, the iris, to discover factors which play an important role for the prevention and treatment of illnesses, but also for the preservation of an optimum health.

One of the advantages of the iris diagnosis consists in the fact that it is able to pro-vide a lot about the state of the health of a person. An iris picture can point out a health problem. For example, the fact that more than only one single organ is concerned or that the problem also has an emotional or mental component. Thus one can discuss much better with a patient who must decide between different possibilities of treatment much better or initiate preventive measures before the illness comes to the outbreak.

The iris diagnosis has set up in many countries a complementary-medicine discipline. Thanks to her special qualities the iris diagnosis is able to cross some borders which have been established in the last decades with the heavyweight on „evidence-based medicine“ in the medical science. The iris diagnosis is an easy diagnostic method that gets by without big apparatus expenditure and the costs linked with it. It gives to general doctors and also other holistically working therapists a secured diagnosis instrument in the hand.

The iris diagnostic is one of few disciplines which pull up the eye for the diagnosis position. Ophthalmologists already know this; they judge the ocular inside around illnesses to ascertain. Besides, they know some illness signs with which the iris diagnosis works and they are of use already.

In addition, there are investigations with the help of the irises to derive the constitutional type – namely the basic disposition of the individual as well as his personality picture. This constitution decides on it for which problems and illnesses an individual is especially susceptible. Moreover, the preserved information about the personality type can be pulled up for the composition of teams.

The aim of the project is to develop an automatic iris image acquisition and diagnosis system. The development of algorithms and procedures for the analysis of the structure inside the iris, the color information and the patterns on the irises that can be automatically used together with the expert's knowledge on illness pictures.

In Section 2 we describe the state-of-art of iris diagnosis. The image acquisition and the preprocessing is described in Section 3. The case-based object recognition method is described in Section 4. Results on the image acquisition, the preprocessing, and the recognition of the iris are given in Section 5. In Section 6, we explain the algorithm for pupil recognition,

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orange brown spot recognition, and topological matching. Finally, we give conclusions in Section 7.

II. Related Work

An automatic system to the iris diagnosis does not exist up to now. Presently the international state of the iris diagnosis is the evaluation of the irises by trained remedial practical people or medical doctors. For the education of the remedial practical people and the medical doctors there is a huge number of the certified training institutes who provide the Iridology with the help of examples and exercises. In Germany, the Felke institute is to be called moreover. In addition, there are a huge number of books in those the expert's knowledge amassed for decades are given. A lot of experience of the Iridology is given by image examples by doctors or remedial practical persons. Accordingly, the Iridologist must take part for life in trainings to extend his knowledge reservoir and to freshen up it. The institutes collect continuously se-cured examples (picture again to be able to coach anamnesis and diagnosis of a per-son) around professional guilds corresponding in this material. That is the expert's knowledge is built up at the doctor and remedial practical person only about many years. Nevertheless, the subjective influence continues by the human judgment of the picture of the irises. It is hardly provable which doctor or remedial practical person is a real expert in the area of the Iridology and who not. Seriously medical studies on the iris diagnosis for skin cancer analysis and cervix cancer analysis show this problem and other subjective factors that influence the result [10][11]. Therefore, an automatic system will contribute to provide objective evidence and the capability for the reproducibility of the Iridology.

In Germany offers e.g. the company H. Kieberger in Giesbach a medical scope [2]. The Medical Scope is held in the hand and can take up in each case only one-iris image. With such a system no optimum picture admission of the irises is possible. The achieved image quality remains doubtful. An automatic picture improvement or even picture evaluation does not offer the Medical Scope. The company offers a multimedia teaching program, which provides the knowledge of the iris diagnosis and can be used interactively for the image diagnosis by manually looking up the multi-media catalogue and choosing the diagnosis result of the image that looks most similar to the recent image. An automatic evaluation cannot be done with this procedure.

In Asia, where alternative remedial methods have traditionally a good image, are found in the scientific literature [3][4] isolates examples of the automation of the iris diagnosis. It is described the automatic fit [3] of the topographic map of the iris on the individual iris or the use of the iris diagnosis for the determination of the pancreas condition [4]. A comprehensive automatic evaluation of the iris concerning the iris diagnosis is not found. Therefore, the works can be only seen as the first step in the direction of automatic iris diagnosis. The works did not flow into a commercial system.

That the investigation of the iris for the recognition of illnesses is of interest shows a study of the John Hopkins's center for the diagnosis of Multiple Sclerosis (MS) [5]. Here an easy eye scan allows recognizing Multiple Sclerosis. Also other work from the psychiatric research exists, which proves, that the arrangement for depression and other psychiatric illnesses [6] can be recognized by the irises.

Otherwise, the iris recognition is only used in the area of the security research for the identification of person [7]. Here it is still a problem whether the irises is taken when the person stands still or in the running of a person. In contrast to the iris recognition, the iris diagnosis demands a more exact resolution and more detailed evaluation of the irises. In addition, illnesses of a person have influence on the iris recognition. Hence, it is to be expected that this project will give another technological impulse to the iris recognition besides the iris diagnosis.

Scientific studies [8] [9] show furthermore that the iris characteristic correlates with the personality and the behavior of a person and points to depressive illnesses [6]. Therefore, another influence of the technology could also be to be seen in the area of sociology, team arrangement and personality profile analysis.

III. Image Acquisition

The aim of this work was to develop an easy useable image acquisition unit that allows a person to inspect his iris by himself.

To understand the conditions necessary for iris image acquisition, we first started with the normal microscopic setting of the ophthalmologist. This image acquisition unit consists of an ophthalmologist microscope with a special locking of the head, a white lamp and a digital camera CANON AS 710. The magnification of the lens is 450x. The light is irradiated into the eye with an angle of 45 degree. Note, the eyeball is a moving objects therefore it is not possible to position the light reflex point into a certain part object of the eye.

The image has been taken by a human after having found the right focus level and a sharp image. The resulting digital images are shown in Fig. 1a-b.

It is a single shot image not a movie. Such an image acquisition unit cannot be used by human by himself.

Fig. 1a, The image cut out of the microscope

Fig. 1b, The rectangular cut out of the image in Fig. 1a,

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The second choice was a handheld microscope with a ring of four white light lamps and a 400-x magnification. The microscope was equipped with a gum eye muscle in front of the microscope to ensure safety image acquisition for the person, no foreign light irradiation and a defined image acquisition distance to the object. There is still a manual focus. A sequence of images is taken and the best images of this sequence are cut out for further evaluation. Some sample images of three different subjects are shown in Fig. 2a-c.

		
Fig. 2a, Iris of Subject_1	Fig. 2b, Iris of Subject_2	Fig. 2c, Iris of Subject_3

The iris is never fully centered in the image. Sometimes we get only part of the iris. Sometimes we have the lid in the image and sometimes not. That is because we cannot lock the eye in front of the camera. The light reflection points are a bit annoying-ly. However, that are white spots in the image and they can easily be removed. Un-fortunately the area under the white spots is not useable for diagnosis anymore. The setting of the light reflection points into the pupil would be much more preferable but since the eye is moving it is almost impossible unless the observer is waiting for the time were the light reflection points are perfectly located inside the pupil.

IV. Detection of the Iris by Case-Based Object Recognition

We first need to find a reference point in the image. Our reference point is the pupil of the eye. From the center of the pupil, we set out a circular model and match this mod-el against the image contours. Where the image points give the best fit with the model is the boundary of the iris located. Based on the color we can judge how much area the iris will cover in the image. The iris is colored while the surrounding is white or skin-type color.

The model can be a general model such as a circle or different types of models taken from different example images such as described in [12]. We choose the later approach and use case-based object recognition [12] for the detection of the iris.

A. Case-Based Object Recognition

Our case-based object recognition systems architecture is shown in Fig. 3.

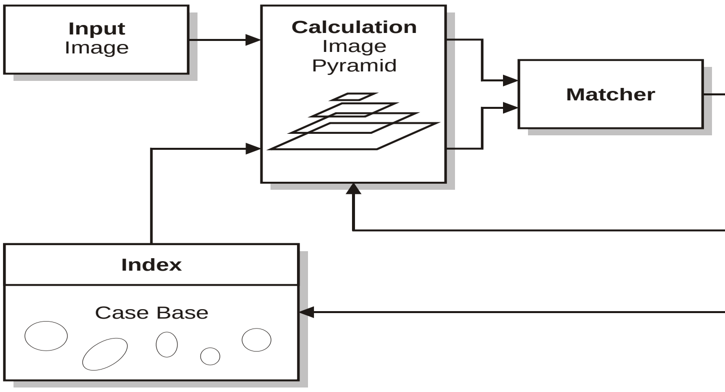

Fig. 3, Architecture of a Case-Based Object Recognition System

An index over the case base should allow us to find the closest case among the numerous cases in short time. A case image is matched against the image by constructing an image pyramid from the actual image and the case image. This allows us to reduce the computation time while matching. Beginning with the highest level of the image pyramid, the scores are calculated and the areas of interest are marked. The area of interest is the area where an object can be detected. This area is recursively used for further matching by going downward the levels of the image pyramid. Finally, the closest match is given to the output.

The heart of our case-based object recognition system is a case base of shapes. These shapes are represented as contour chains. Therefore, a case is comprised of a set of contour points $S_c = \{s_c(x_o, y_o); 1 \le c \le n\}$ where each contour point has the grey value 1 and a class label for the shape. Based on this information we can transform the shape from the contour point list into a 2-D image matrix, further called case image. The case base is filled up for the actual application by shapes that we learnt based on our novel case acquisition and case mining method [12].

Depending on the actual value of the similarity measure, the next level of the index structure is selected and the process repeats until a final node is reached.

B. Case Representation

In general, we can distinguish between three different case representations according to the pixels that are used for matching:

1. Region of Interest (ROI): A region of interest ROI is obtained by taking a cutout from the original image. All pixels of the obtained image matrix are used as case pixels regardless if they are object or background pixels.
2. Object Case: In the image matrix shown in Fig. 2b are only used those pixels as case points that lie inside and at the contour of the object. In this case, the shape and the inner structure of the object are taken into consideration.

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3. Contour Case: Only pixels that lie on the contour of an object are taken as case points. Thus, only the shape of the object of interest is matched.

The kind of representation used for the cases depends on the special image quality the matcher should detect. Our goal is to recognize the fungi spores. To use an object case would not be sufficient for our application since the appearance of the structure inside the objects is very diverse and because of that it would result in a case base where for each case is stored an object. The only representation that gives us a more generalized view to the objects is the shape. Therefore, we use a contour case as case representation.

Note that an object might appear in an image with different size and under a different rotation angle and on various locations in an image. However, it is still the same object. It makes no sense to store all these identical but different sized and rotated objects in the case base. Rather there should be stored a unit object with the origin coordinates x0 and y0 that can be translated, resized and rotated during the matching process. Therefore, the case pixels $\vec{p}_k = (t_k, u_k)^T$ and the direction vectors $\vec{m}_k = (v, w)^T$ have to be transformed with a matrix A to (1):

$$\begin{aligned} \vec{p}\,'_k &= A \cdot \vec{p}_k \\ \vec{m}\,'_k &= A \cdot \vec{m}_k \end{aligned} \tag{1}$$

If φ denotes the angle of rotation and r the scaling factor the matrix may look like the following:

$$A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} = \begin{pmatrix} r\cos\varphi & -r\sin\varphi \\ r\sin\varphi & r\cos\varphi \end{pmatrix} \tag{2}$$

C. Image Representation

Since we are looking for the contour of the object which is the boundary between the background and the object and which is usually an area of high grey level chance we are representing the image by the edges. The edges can be represented by the gradient of the pixels. In order to determine the gradient, first the direction vector $\vec{z}_{(x,y)} = (\Delta x, \Delta y)^T$ of a pixel at the position (x, y) is calculated from the grey level matrix. The direction vector indicates the change of the grey value in vertical and horizontal direction respectively. The length of this vector is equal to the gradient and it is commonly determined from the direction vector through the following formula:

$$\left\| \vec{z}_{(x,y)} \right\| = \sqrt{(\Delta x)^2 + (\Delta y)^2} \tag{3}$$

Due to the discreteness of the grey level matrix, which represents the grey value function only in some well-chosen points, the direction vectors cannot be calculated by the known analytic derivation formula. Therefore, many operators were developed that allow us to determine the direction vectors from the grey level matrix. We used the Sobel operator. The corresponding edge image is obtained by applying such an operator to the grey level image. After that, the pixels represent the gradient instead of the grey level value. Besides that, the direction vectors for each pixel are stored. This representation is calculated for the case and the actual image before the matching.

D. Similarity Measure based on the Dot Product.

As we have pointed out above the calculation of the Hausdorff distance is more costly than the calculation of the cross correlation. While we have to search for correspondences between case and image pixels in case of using the Hausdorff distance, we evaluate the image pixels that coincidence with the case pixels by using the cross correlation. On the other hand, we are interested in matching oriented edge pixels. Therefore we propose a similarity measure based on the cross correlation and by using the direction vectors of an image. This approach requires the calculation of the dot product between each direction vector of the case $\vec{m}_k = (v_k, w_k)^T$ and the corresponding image vector $\vec{i}_k = (d_k, e_k)^T$:

$$s_1 = \frac{1}{n}\sum_{k=1}^{n} \vec{m}_k \cdot \vec{i}_k = \frac{1}{n}\sum_{k=1}^{n} \left\langle \vec{m}_k, \vec{i}_k \right\rangle = \frac{1}{n}\sum_{k=1}^{n} \left(v_k \cdot d_k + w_k \cdot e_k \right) \tag{4}$$

with $k = 1, \ldots, n$ case pixels.

The similarity measure of Equation (4) is influenced by the length of the vector. That means that s1 is influenced by the contrast in the image and the case. In order to remove the contrast, the direction vectors are normalized to the length one by dividing them through their gradient:

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$$s_2 = \frac{1}{n}\sum_{k=1}^{n}\frac{\vec{m}_k \cdot \vec{i}_k}{\|\vec{m}_k\| \cdot \|\vec{i}_k\|} = \frac{1}{n}\sum_{k=1}^{n}\frac{v_k \cdot d_k + w_k \cdot e_k}{\sqrt{v_k^2 + w_k^2} \cdot \sqrt{d_k^2 + e_k^2}} \quad (5)$$

In this respect, the similarity measure differs from the normalized cross correlation (NCC). The NCC normalizes each pixel value by the expected mean of all values of the considered pixels. Therefore, the normalized cross correlation is sensitive to non-linear illumination changes while our method is not because it takes only into account the angle between two corresponding direction vectors.

The values of s_2 can range from -1 to 1 (see Fig. 4). If s_2 is equal to one then all vectors in the case and the corresponding image vectors have the same direction (see Fig. 4a and Fig. 4b). If s_2 is equal to -1 then all the image vectors have exactly opposite directions as the case vectors. That means that only the contrast between the case and the image is changed (see Fig. 4a and Fig. 4c). The similarity values for these image constellations are also shown in Fig. 4.

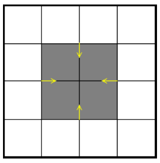
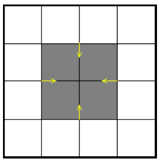
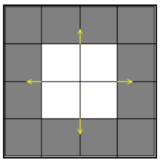
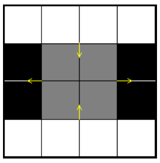
(a) Case	(b) Object with identical Contrast	(c) Object with globally inversed Contrast	(d) Object with locally inversed Contrast
			
s_1	1	-1	0
s_2	1	1	0
s_3	1	1	1

Fig. 4, The Effect of Contrast Changes to the Scores of the Similarity Measures

The above described global contrast changes can be excluded by computing the absolute value of s_3:

$$s_3 = \left| \frac{1}{n}\sum_{k=1}^{n}\frac{\vec{m}_k \cdot \vec{i}_k}{\|\vec{m}_k\| \cdot \|\vec{i}_k\|} \right| \quad (6)$$

However in case half of the vectors have the same contrast and the other half have the opposite contrast than the similarity based on s_3 is zero. That might not be preferable for cases where objects are touching. To avoid this we calculate the similarity based on s_4:

$$s_4 = \frac{1}{n}\sum_{k=1}^{n}\frac{\left|\vec{m}_k \cdot \vec{i}_k\right|}{\|\vec{m}_k\| \cdot \|\vec{i}_k\|} \quad (7)$$

V. Results

The original images (see Fig. 6a-c) are transformed into a grey level image. The threshold image used to find the pupil and the center of mass inside the pupil is shown in Fig. 7 a-c for three subjects. Around the center of mass is set the model and then object detection is started. The edge-filtered image by Sobel-phase operator is shown in Fig. 8 a-c for the three subjects.

Fig. 6a, Iris of Subject_1	Fig. 6b, Iris of Subject_2	Fig. 6c, Iris of Subject_3

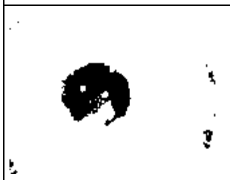



Fig. 7a, Threshold image	Fig. 7b, Threshold image	Fig. 7c, Threshold image

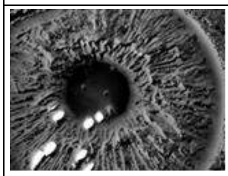
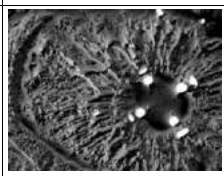
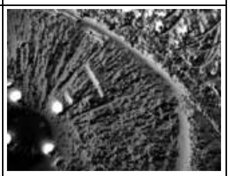

		

Fig.8a, Edge image	Fig.8b, Edge image	Fig.9c, Edge image
		
Fig. 9a, Detected Iris Area	Fig. 9b, Detected Iris Area	Fig.9c, Detected Iris Area

The resulting image after applying the case-based object matcher is shown in Fig. 9 a-c.

Twenty subjects participated in this study. From each of the subject were taken the iris with the handheld microscope. Four different models were inserted into the case base of the case-based matcher ranging from circular to ellipse-like model. These ellipse-like models are flattened at the bottom and the top as how it appears on the normal eye. Each of the images was preprocessed in the same way as the three images described above.

The iris could be detected by our method in all of the twenty cases. However, due to occlusion, not the full iris could be seen in the image and part of the detected object needs to get removed afterwards. This removal can be easily done by the color information since it is mostly skin and hair that occludes the iris.

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VI. Detection of PuPil and Colored Spots

We are looking for dark or colored spots in the iris and assign these spots to the landscape of the iris (see Fig. 10a-b). These two landscape represent the knowledge of an iridologist that has been built up over many years. The regions in this 2-d spatial representation are assigned to specific organs or diseases. A spot in a particular area speaks for some dysfunction of the specific organ.

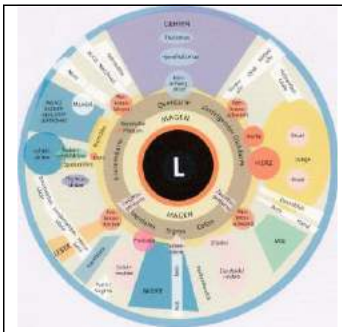
Fig. 10a, Topological Map of the Left Eye

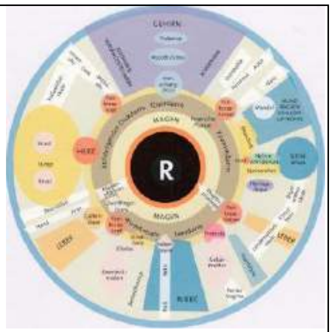
Fig.10b, Topological Map of the Right Eye

First, we have to find the white spots of the lamp in the image and mark them as blind areas that are not considered for the diagnosis. Then we have to find the pupil of the iris. Figure 11 shows the original image. We invert the color image to a grey scale image, normalize it to 0-255, and smooth it with a median filter afterwards in order to get only the bigger white areas. We mark the areas with the grey-level equal or near white and use this image as a mask for further processing.


Fig. 11a, Spot at top left in Original


Fig. 11b, Grey Level Image

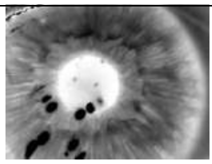
Fig. 11c, Labeled Lamp Spots

Then we find the pupil area within the iris area. In the inverted grey level image is the pupil the largest light patch. We binarize the image with a fixed threshold (g=178, see Fig. 12a).


Fig. 12a, Labeled Pupil


Fig. 12b, Pupil after Morphological Filtering

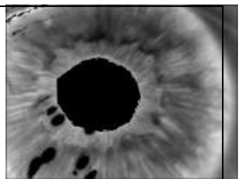
Fig. 12c, Labeled Pupil Area and Lamp Spot Area

Then we label objects in the image with the contour following technique. We get the features roundness and size and we remove small objects based on the rule R1: IF roundness=best and size=largest THEN remove objects with flood fill small. Since there are still some objects left, we further process the image by applying two times the operation dilatation (see Fig12b). Now, we find the center of mass of the pupil and place our landscape of the iris into the image.

The spot at the top_left is found by color thresholding. We search for orange brown spots in a blue iris. This is very common spot for blue irises. As result, we get the marked area of the spot in the iris (see Fig. 13a). In the next step, we have to assign an area of the topological map to this spot for the respective side left or right. Therefore we center the map in the pupil and compare the marked area of the spot to the map. Afterwards we assign the decision to this image. The iris shown in Fig. 13b we compare to left eye map and assign the diagnosis “problems with the forehead cave”. Now the diagnosis has been done manually. The development of a fuzzy topological matching algorithm is left for further work.


Fig 13a,. Labeled orange brown spot in the iris

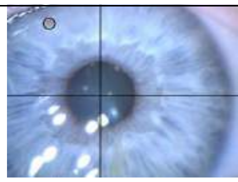
Fig. 13b, Labeled Image with pupil centered topological map

VII. Conclusion

In this paper we have presented our work on image acquisition, preprocessing and iris recognition for Iridology. We have used a handheld microscope with a ring of white lamps and equipped with a gum eye muscle in front of the microscope to ac-quire the iris. From the image sequence is take the image that shows most of the iris and is sharp enough for further analysis. The iris is detected with our case-based object recognition methods using different models from circular to ellipse-like models. We were able to recognize the iris of our entire subjects with good quality. Occluded areas could have been taken out based on the color information and they are not used for further evaluation. Furthermore, we have presented our algorithm for the detection of the pupil and colored spots in the iris. Light reflection points have to be detected and marked as blind spots in the iris. They cannot be used for further diagnosis. Then the topological map is centered in the pupil and the location of the spot has to be matched against the topological map in order to find the diagnosis. This has been done manually in this work. To develop a Fuzzy topological matching algorithm is left for further work.

The detection of orange brown spots is not the only abnormality that can be seen in the iris. To develop a catalogue of such anomalies for the different iris types is left for further work. Once the catalogue is set up, we have to develop the

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respective image analysis procedures for the detection and description of the different anomalies in the iris. At the end, we have to set up a system concept that allows us to more or less automatically to inspect different iris types.

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