GREiF - graphical documentation of retinal findings using a standardized digital symbol library

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Abstract

Aim: *To develop a software package that improves standardized clinical documentation of retinal findings. In clinical routine retinal findings are usually documented with sketchy free-hand drawings and supplementary handwritten remarks. Documentation features of common ophthalmologic software products include only simple sketching functions, which are limited to change location, size or colour of graphical primitives (e. g. ovals, rectangles, lines, textboxes ...). As a result a feasible creation of standardized graphical documentations in retinal imaging is almost impossible.*

Methods: *We developed a java-based software tool that features quick and intuitive generation of fundus schemes, which can be printed as findings sheet or digitally archived. Particularly for clinical ophthalmologists we created a set of standardized symbols, which can be digitally rendered for graphical documentation. All symbols were integrated into a graphics library and separated in specific categories: "Preoperative", "Postoperative", "Angiomas and tumours", "Retinopathy of the premature". The required symbol can be chosen from the library and is simply modelled on the retina scheme by placing anchor points with mouse clicks.*

Results: *Practicability of existing features for graphical documentation of retinal findings is not sufficient, because free-hand drawings are too time-consuming and besides share the risk of false interpretation due to individual handwritings. In contrast to free-hand sketching our software tool not only applies a faster way of graphical creation but additionally improves medical documentation using a standardized symbol library, which also is specifically categorized.*

Conclusions: *Graphical symbols for retinal documentation have found universal acceptance in ophthalmologists for a long time but still the practical use is not efficient in clinical routine. This report shows how the adequate use of software technology can contribute to documentation quality and clinical practice.*

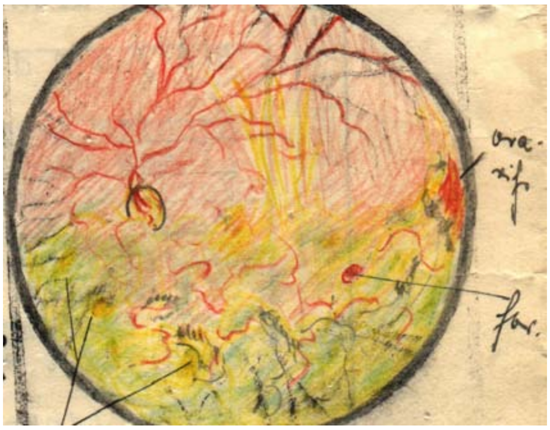
1. Background and motivation

Although the technical solutions for medical imaging in ophthalmology improved dramatically, the free-handed, paper-based fundus scheme is still standard in clinical routine. One reason for that is that high-cost hardware is not affordable for all various clinical situations, another is the fact that these days funduscopy (photographical documentation) of the peripheral retina is still time-consuming and in most of the cases only small parts of the retina become observable. To enable the ophthalmologist to document the retinal findings in the familiar way we have developed a software solution named GREiF (Greifswald Retinal Imaging and Funduscopy) which emulates the use of a pencil and a sheet of paper on a monitor in connection with a (tablet-)PC-pen or a mouse.

2. Improving graphical documentation of retinal findings

2.1. Status quo: freehand sketches

Using free-handed and paper-based fundus sketches in clinical ophthalmological routine has been a reliable way of documentation since the invention of ophthalmoscopic techniques [AD28], [Mor79]. Figure 1 shows a historical fundus sketch that was created at the University Eye Hospital Greifswald in 1935. The drawing is rich in detail therefore its creation is too time-consuming for today's clinical working conditions. The lack of standardized symbols forced the author to add hardly legible hand-written remarks. Furthermore this example demonstrates how unstandardized documentation may lead to misinterpretation: retinal attachment was painted with yellow cross hatch, although the standard color for retinal attachment is blue while yellow normally indicates retinitis. Today's documentation quality even decreases due to lack of time (Fig. 2).



In the past retinal findings were documented with time-consuming detailed drawings. Unstandardized symbols shared the risk of misinterpretation.

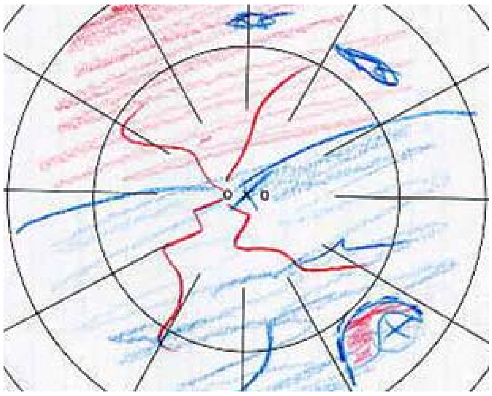
Figure 1: *Historical fundus sketch of 1935.*

Although it seems that medical imaging in ophthalmology (e. g. OCT of the macula) has been improved enormously there are still limits in the documentation of peripher retinal findings. For example mobile, handy panoramic cameras are not available yet and most of the high-tech examination systems are too cost-intensive for the comprehensive use. In case of cataract (opacity of ocular lens), kinetic tremor or during eye surgery the fundus sketch will still be needed. Following the proverb "A picture is worth a thousand words" a clear fundus sketch is more descriptive than verbal or written documentation [BWHS02]. The risk of loosing relevant information due to the patient's contact to several specialists and services seriously has to be taken into consideration. So the proper documentation has to be seen as a very important part in medical treatment, especially when it comes to legal measures.

2.2. The software eases fundus sketch creation

Although that fundus sketches are more uprated than a verbally description there is only one report of a software-based graphical documentation of pathological retinal findings. The software-program named Superpaint was presented in 1989, so that the program had a rather low technical standard [EWR89].

We now developed a software tool that is as easy - or even easier - as the former way of handwritten documentation. After a short time of familiarisation with the menu navigation a fundus sketch can be made very easily and quickly on a tablet- PC or a PC-Monitor (Fig. 3). Due to the standardized



Today retinal findings are still documented with freehand drawings but the lack of time leads to decreased documentation quality.

Figure 2: *Modern fundus sketch of 2008.*

and self-explaining symbol library and to the recognizability value even among intermediate colleagues the handling is easy.

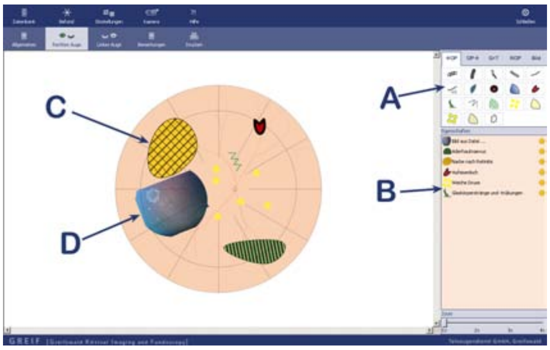
Best usability can be achieved running the software on a tablet-PC. This emulates the familiar way of documentation with a pen and a sheet of paper.

Figure 3: *Using the GREiF software on a tablet-PC.*

2.3. Digital symbol library ensures standardized documentation

The digital symbol library which was developed especially for GREiF, allows a standardized interpretation for all users. In everyday routine not only the quantity of different symbols [Aug01] but also the variability of forms, complexity, detailedness and colouring complicate an explicit documentation. Furthermore it is time-consuming to find seldom used symbols for rare retinal findings. In addition to that the quality of handwritten symbols depends on the user's creative ability which cut down considerable restrictions on their informative value. For the first time GREiF offers a digital symbol library with 58 different symbols. To make all symbols easily accessible and to present the digital symbol library clearly structured we categorized it into four different categories (Fig. 4A):

1. Preoperative
2. Postoperative
3. Angiomas and tumours
4. Retinopathy of the premature (ROP)

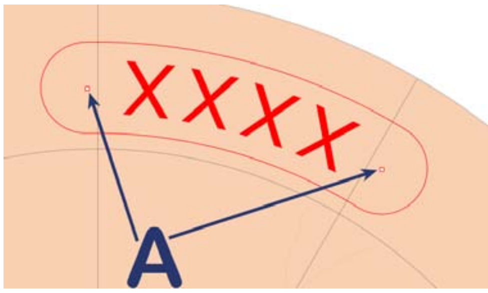


The GREiF GUI components enable self-explanatory and structured usability. A: 4 specific categories contain a total number of 58 symbols, B: Stack of layers, each symbol is organized in a separate layer, C: Schematic retina with different symbols, D: Imported fundus camera image.

Figure 4: *The GUI of the GREiF documentation software.*

A symbol can simply be chosen and modelled on the retina scheme placing anchor points with mouse clicks (Fig. 4B). According to complexity the symbols can be changed in their position, size and shape using their anchors. A symbol can have either a fixed number of anchors (Fig. 5) or even an unlimited number of anchors whenever graphical freeform capability is needed (Fig. 6).

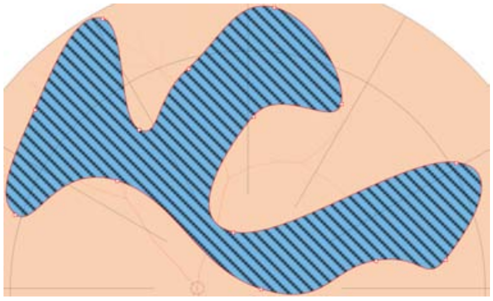
A further powerful feature is the use of layers: each symbol is organized in a separate layer which can be edited apart from any other layer (Fig. 4B). Together, all the layers form a stack of symbols that will be rendered to the image. In case of different pathologic retinal findings in identically locations it is possible to show the symbols in a semitransparent way or fade them out. To avoid misinterpretation of created symbols it is imperative to keep a symbol's filling pattern constant even if an existing symbol is modified: e. g. vertical cross hatch has a different meaning than diagonal has. This feature was implemented as a two-dimensional projective texture mapping which guarantees constant texture images indepedent from symbol transformation. Photographic retinal findings that show mostly only a small part of the retina can be imported into the computer-based retinal sketch if required (Fig. 4D). In summary we can say that this software



Symbols with predefined shape need only a fixed number of anchors for creation or transformation. This example shows a degeneration that requires only two anchors (A) thus it was created with two mouse clicks.

Figure 5: *A symbol with a fixed number of anchors.*

generates high quality graphical documentation with just a few mouse clicks (Fig. 7).



Symbols without predefined shape can have any shape. As a result they need to have infinite anchors to make the creation of graphical freeforms possible. The example shows a complex freeform with 13 anchors.

Figure 6: *A symbol with an unlimited number of anchors.*

3. Exploitation and commercialization

To obtain an optimal technology transfer all three authors successfully founded the TDi Teleaugendienst GmbH, Greifswald, as a spin-off of the University of Greifswald in the summer of 2007. The company developed the GREiF software as a java-based software tool so that it runs on every common PC or tablet-PC. To date more than 5000 single user licenses of the german version were sold for german, austrian and swiss ophthalmologists. Further languages as well as network and clinical information system integration have actually been initiated to increase distribution. The present success of our first digital documentation tool already led to the development of a further product, a software tool for the documentation of contact lens complications [JRGT08]. And there is still more to come but this is a corporate secret at the moment.

4. List of relevant publications

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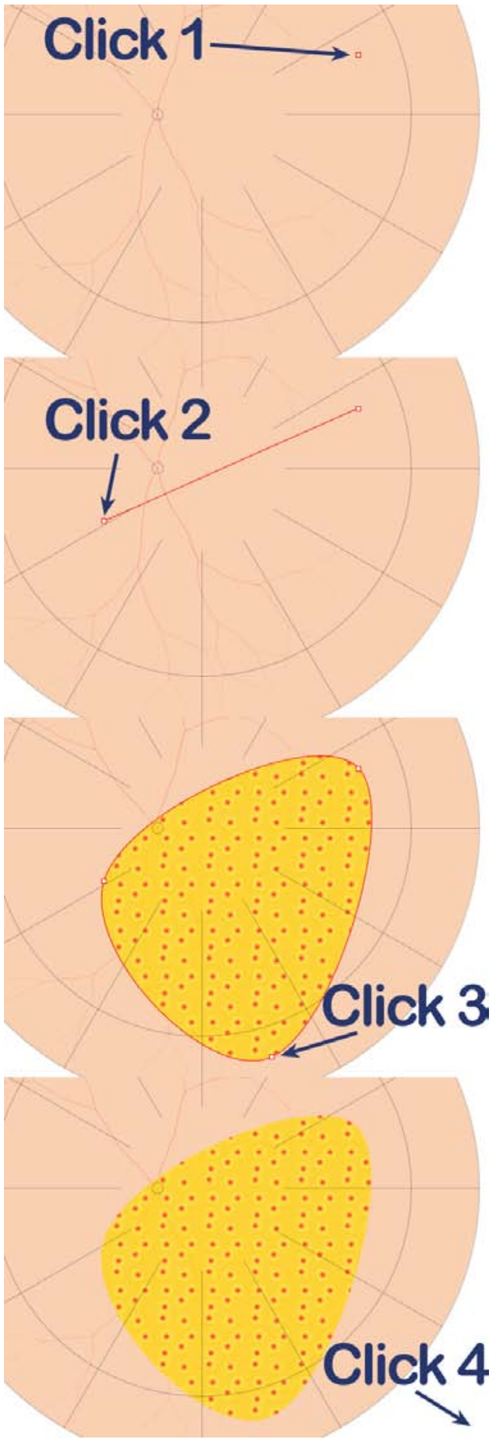

A sequence of only four mouse clicks is necessary to generate a graphical symbol within a few seconds.

Figure 7: *Example of creating a graphical symbol.*

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