Please delete place marker and replace with your own picture

Title of Thesis

Place your subheading here

Description of thesis (semester- / Bachelor thesis / etc.)

[Insert short text (abstract) if desired]
This document serves as a template for the compilation of reports according to the guidelines of the BFH. The template is written in LATEX and supports the automatic writing of various directories, references, indexing and glossaries. This small text is a summary of this document with a length of 4 to max. 8 lines.
The cover picture may be turned on or off in the lines 157/158 of the file template.tex.

Degree course:	[z.B. Electrical and Communication Engineering]
Authors:	[Test Peter, Müster Rösä]
Tutor:	[Dr. Xxxx Xxxx, Dr. Yyyy Yyyy]
Constituent:	[Wwwww AG]
Experts:	[Dr. Zzzz Zzzz]
Date:	07.02.2014

Versions

Version	Date	Status	Remarks
0.1	01.08.2013	Draft	Lorem ipsum dolor sit amet
0.2	21.08.2013	Draft	Phasellus scelerisque
0.3	02.09.2013	Draft	Donec eget aliquam urna. Lorem ipsum dolor sit amet
1.0	26.01.2014	Final	Lorem ipsum dolor sit ametPhasellus scelerisque, leo sed iaculis ornare
1.1	31.01.2014	Correction	Layout changed
1.2	07.02.2014	Addition	Chapter 1.1 extended

Management Summary

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Contents

1. Introduction

This document serves to illustrate the LaTeX template on the basis of the corporate design of the Bern University of Applied Sciences as well as a manual for its use. It is assumed that the user already has some experience with LaTeX or is willing to familiarize with the subject. In the bibliography the user finds some useful information on LaTeX on various books and documents on the Internet.

1.1. Organising Documents

This document is structured according to the documentation of a project work or a thesis. In Chapter 2, the packages used are briefly explained, and instructions are given, how the bibliography and the glossary are to be used. Chapter **??** presents a sample chapter to audit the type area.

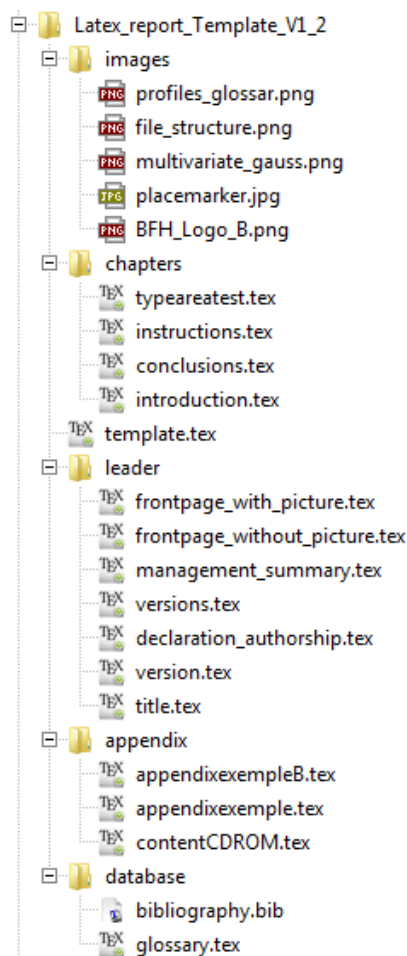In figure 1.1 the file structure is shown for this template.

Figure 1.1.: File structure

1.2. Contact

The manufacturers of this template welcome any suggestions for improvement. Chapter 1.3 shows possible suggestions for improvement.

First Name Last Name	E-mail	Function
Alfred Kaufmann	alfred.kaufmann@bfh.ch	Employer, Project Management, Supplements, Improvements
Fritz Dellsperger	Retired	Tips on the structure and layout
David Burri	Contracted out	First compilation of the Template

Table 1.1.: Contact Persons

1.3. Suggestions for Improvement

- Create a BFH Style Files
- Template for the Compilation of presentations with LaTeX

2. Instructions

The following table shows some of the most important packages used in the LaTeX template.

Package	Function
cmbright	sans serif font "Computer Modern Bright", which supports text encodings OT1, T1 and TS1, as well as the mathematical signs and AMS symbols
ae	provides better resolution fonts in PDF files
fancyhdr	easy adjustment of head- and foot lines
graphicx	integration of graphics in LaTeX documents
booktabs	better presentation of tables
textpos	simplified and absolute positioning of boxes on the page
hyperref	package to complie links into PDF files
geometry	simplified and improved adaptation of the standard type area
makeidx	simple Index compilation (see section 2.1)
glossaries	compilation of glossaries (see section 2.2)

Table 2.1.: Packages

2.1. Subject Indices

LaTeX is not able to create an Index in the basic configuration. This can be created in LaTeX with the `makeidx` package and the `makeindex` program. The following page contains a detailed explanation of how the package works, and its application:

http://en.wikibooks.org/wiki/LaTeX/Indexing

Roughly summarized the following points are needed for an index:

- Embed the package `makeidx`.
- Initialize the compilation with the command `\makeindex`.
- Continuously initializing words in the text with the command `\index{}`.
- During the first passage of the document's compilation, the directory is created and definitions marked with `\index{}` are stored in the `.idx` file.
- During the second passage the `.idx` file is sorted, formatted and stored as `.ind` file whereas LaTeX then inserts the `.ind` file into the document.

2.2. Glossay

A glossary can also be created in LATEX with the `makeindex` program and the `glossaries` package. The following list shows the procedure to generate a glossary:

- Integration of the package `glossaries`.

- If necessary, a personal database may be created including glossary entries. This template works with such a database, which is stored in the `database` folder. Entries from the database are only written in the directory if the word in the text is actually stated.

- With the `\makeglossaries` command a new compilation is initialized.

- New entries can be created with the command
  `\newglossaryentry{<SHORTCUT>}{name={<NAME>},description={<DESCRIPTION>}}`.

- In the text continuously referencing words with the command `\gls{<SHORTCUT>}`.

- Similar to the compilation of the index, the directory is only embedded into the document during the second passage.

In order to work accurately, the glossary must be compiled with `makeindex` after post-editing the document. For this the following code in the command line is to be executed:

```
makeindex -s template.ist -t template.glg -o template.gls template.glo
```

With most LATEXeditors, this can be stated as a post-processing step. The following explanation is for the TeXnic-Center program. Under the menu "Build" > "Define Output Profile..." (short: alt + F7) in the "Postprocessor" register, the window shown in Figure 2.1 can be found. Then it is necessary to insert a new entry, when an application as well as an argument must be specified. The application can be found in the MiKTeX installation (`..\MiKTeX X.X\miktex\bin\makeindex.exe`). As an argument, the following line must be entered:

```
-s "%tm.ist" -t "%tm.glg" -o "%tm.gls" "%tm.glo"
```
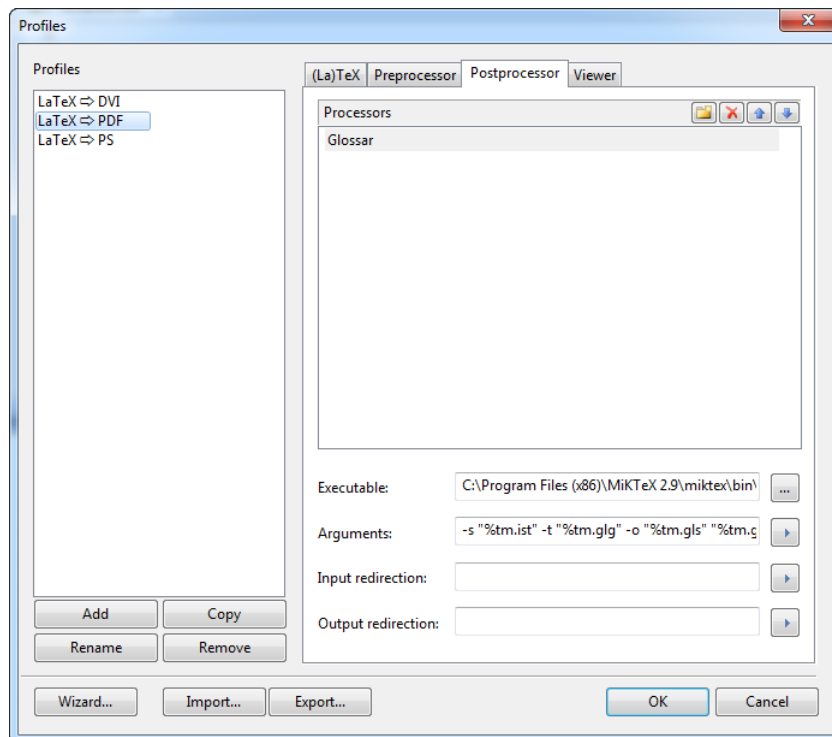

Figure 2.1.: Post-processing

2.3. Bibliography

To compile a bibliography one must resort to BibTeX. The folder `database` includes a `.bib` file with various database entries. How the entries are to be compiled, can be taken from various sources of the Internet or books. The entries in the database will only be written to the directory of the document when the source is actually cited in the text.

Under the following addresses further explanations are found in order to compile the database and its use:

- `http://en.wikipedia.org/wiki/BibTeX`
- `http://www.bibtex.org/`

3. Eye Model

A very important step in hardware and software development is testing. For an eye tracking system it requires a big effort to do this with real data as the information where the participant looks at each time needs to be recorded alongside of the videostream. For this project real time data processing is needed as there is no hardware available on GazelleCompute to encode or store four streams of 120fps with QVGA resolutioni

To optimize the algorithms a simple way of generating new data where the gaze direction and the camera positions are known, would simplify the process.

3.1. What is Important

The 3D-Modeling software to create the model needs to fulfill a few requirements:

- Correct representation of refracting light
- Create animations
- Be scriptable
    - Set position and rotation of certain objects at a certain frame
    - Set camera properties and which camera is active
    - Read the position and rotation of objects at any frame
- (optional)Be free
- (optional)Run on Linux
    - Server that can be used to render runs Linux containers
- (optional)Be easy to learn

Blender is able to match all requirements although the last one might be debatable. You can apply a material properties to a surface. This includes refracting. Rotation and position of objects can be inserted as keyframes and it interpolates the steps in-between.

Blender is also an open source project that is built with Python and has an powerful API that gives access to nearly everything.

3.2. The Human Eye

A side view of a human eye model is visible in 3.1. The camera can only see the front part of the eye. As a result only the cornea, anterior chamber and the iris need to be modeled correctly. The lens can be simplified by a black surface.

It might be counterintuitive that the cornea extends as much out of the eyeball as visible in 3.1. An easy way to verify is to close the eye and move the eyes while holding a finger on the eyelid.
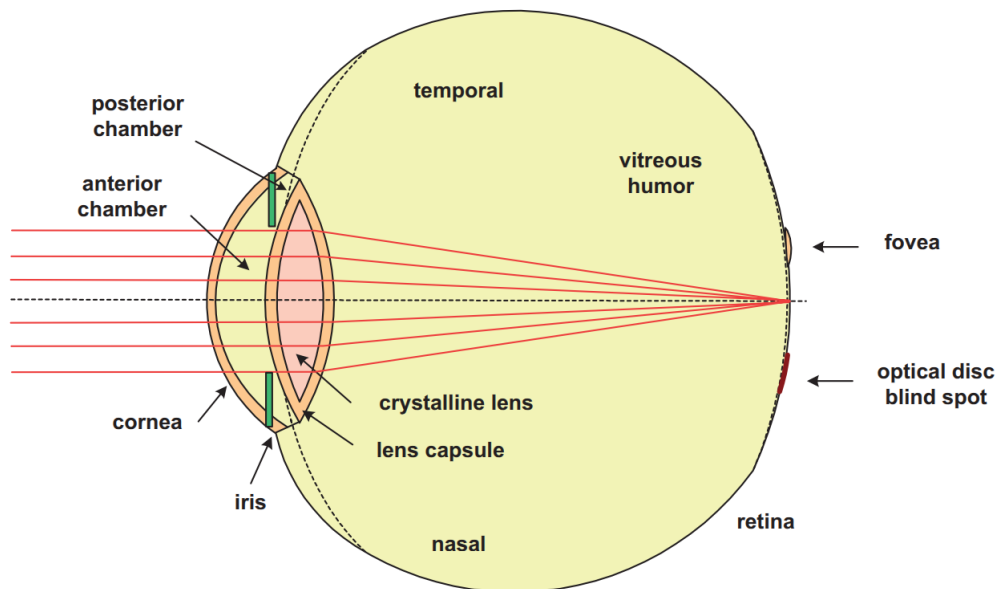
Figure 3.1.: Side view of a human eye model

There are a few models with different values for the refracting indexes, radii and distances but they are close together in most cases. So the simplified Gullstrand eye was chosen.

Notaton	Relaxed			Accomodated		
	Radius r [mm]	Thickness d [mm]	Index n	Radius r [mm]	Thickness d [mm]	Index n
cornea	7.70	0.50	1.376	7.70	0.50	1.376
anterior chamber	6.80	3.10	1.336	6.80	2.70	1.336
crystalline lens	10.0	3.60	1.4085	5.33	4.0	1.426
vitreous humor p	-6.00	17.187	1.336	-5.33	13.816	1.336

Table 3.1.: Algorithmic Complexity of the associative Qt Containers where each element can be accessed over the associated key

3.2.1. Demonstrandum

Quod erat demonstrandum. Seit 1975 fehlen in den meisten Testtexten die Zahlen, weswegen nach TypoGb. 204 §ab dem Jahr 2034 Zahlen in 86 der Texte zur Pflicht werden. Nichteinhaltung wird mit bis zu 245 €oder 368$ bestraft. Genauso wichtig in sind mittlerweile auch Âçcèñtë, die in neueren Schriften aber fast immer enthalten sind. Ein wichtiges aber schwierig zu integrierendes Feld sind OpenType-Funktionalitäten. Je nach Software und Voreinstellungen können eingebaute Kapitälchen, Kerning oder Ligaturen (sehr pfiffig) nicht richtig dargestellt werden.

Subsubsection

This is a typo dummy text. On it you can see if all the letters there are and how they look. Sometimes one uses words like Hamburgefonts, Rafgenduks or Handgloves to test fonts. Sometimes phrases that contain all letters of the alphabet - one calls these sets "pangrams".

Subsubsection

Well known is this: The quick brown fox jumps over the lazy old dog. Often in type dummy texts also foreign-language sentence parts are installed (AVAIL™ and Wefox® are testing aussi la Kerning) to test the effect in other languages. In Latin, for example, almost every font looks good. Quod erat demonstrandum.

3.3. Webstandards

Everywhere the same old story. The layout is complete, the text is slow in coming. This layout is now not naked in space and small and empty occurs, I help out: the dummy text. Created exactly for this purpose, always in the shadow of my big brother "Lorem Ipsum", I look forward every time you read a few lines. Because esse est percipi - being is to be perceived.

And now because you already have the goodness to accompany me a few more sentences long, I would like to take this opportunity to serve you not only as a stopgap, but to point out something that is going to be perceived as deserved: Web viz. See Web standards are the rules that build on the websites. So there are rules for HTML, CSS, JavaScript or XML, words that you might have heard of your developers. These standards ensure that all parties the maximum benefit from a website.
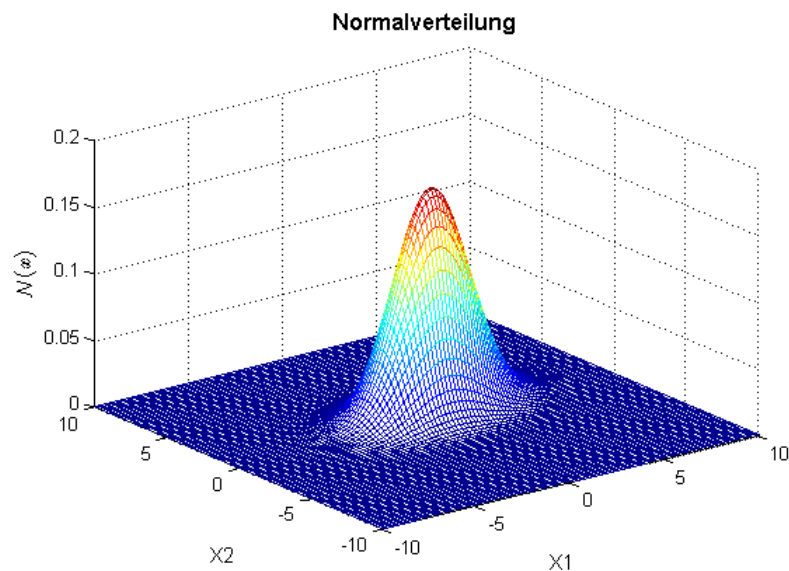

Figure 3.2.: Normal distribution

In contrast to previous websites we no longer need, for example, two different sites for the program Internet Explorer and another browser. It extends a page that - properly applied - both works on different browsers on the net, but just as good for printing or display on a cell phone is. Mind: A site for all formats. What a relief. Standards save time provide for the development costs and ensure that web pages can be easier to maintain later. Of course, only if everyone adheres to these standards.

4. Pupil Detection

4.1. Current State

4.1.1. Overview of Algorithm

The general sequence of the algorithm can be described as follows:

1. Find darkest spot

2. Extract rays starting from the darkest spot from the image

3. Transit the rays with a filter of certain length to detect edges

4. Fit an ellipse on the detected edges with the least square method

The darkest spot is determined by a raster with a fixed distance between points. For each point the average with the surrounding eights point is calculated. The point with the darkest average is the startpoint for the rest of the algorithm.

Outgoing from the startpoint rays are stamped out by the starburst algorithm. This part will run on the FPGA.

For each ray that is stamped out by the starburst the difference to the next pixel is calculated. Because the edge may not lie on a single pixel surrounding differences are added together to build a score for each pixel. This score is positive for transitions from a darker pixel to a brighter. The pixel with the highest score is determined as detected edge. So only edges that transit from dark to bright can be detected.

Every edgepoint is handed over to a weighted least square method to find a ellipse that fits all the points well.

4.1.2. Testing

The algorithm was tested with pictures that were inserted at compile time with the parameters of the ellipse as output. The result was then compared with the result.

4.2. Problem Analysis

4.2.1. Improve Testing

It is very time consuming to generate picture data that can be compiled and to compare the output of the program with what is expected. A better way would be if a algorithm can read any picture or video file and display the result of the algorithm visually on each picture.

The program "Gazelle View" that was developed during the project study can already open and play video files. Because of the modular design of Gazelle View it is simple to insert the algorithm during the decode phase and paint the rays, the detected edges and the fitted ellipse on the image.

All data that was produced by the algorithm may also hold important information to find bugs or problems with the algorithm. In order to display that data besides the frame all data is packed into a struct and displayed in a Treeview beside the frame.
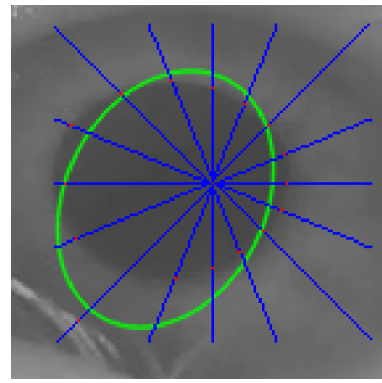
The next step to improve testing would be to automate it and ideally condense the performance of the algorithm to parameters such as the mean and variance of the accuracy.

This should be done on a wide variety of test data, at best with high frame rate pictures that were captured with the eye tracking system. For each of those pictures an ellipse has to be fitted manually and stored as a golden reference. As this needs to be done for a lot of pictures the process of generating the reference needs to be simplified.

4.2.2. Outliers
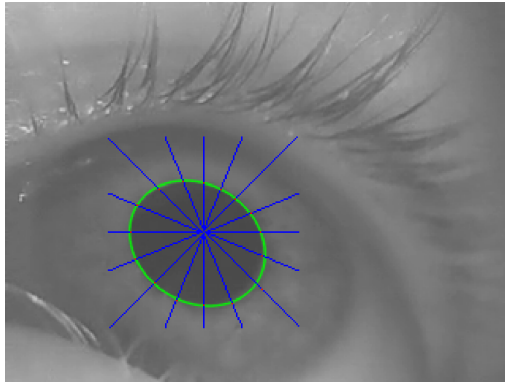
(a) Fitting of Ellipse without outliers   (b) Fitting of Ellipse with one outlier

Figure 4.1.: Comparison between results with and without an outlier

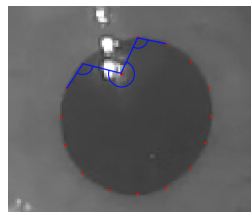## 4.3. Algorithm

4.4. Angle-Validation

To detect outliers it is necessary to find properties that differ strongly from the other transitions. One of those properties gets visible when the angle for each transition gets calculated with the neighbouring transitions.

In figure 4.2a a outlier lies on the bottom left corner of the image and outside of the pupil. The angle of the outlier is very small compared to angle of the neighbouring transitions. Those on the other hand have a greater angle than the other transition points.
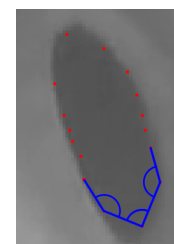
When a outlier is inside the pupil then the situation is reversed as visible in figure 4.2b where the outlier has a big angle and the adjacent transitions very small angles.
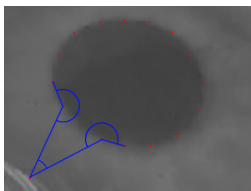
(a) Outlier outside Pupil   (b) Outlier inside Pupil   (c) Accurate Transitions with small Angles

Figure 4.2.: Angles between Transitions around Outliers

Multiple adjacent outliers differ in that it is not possible to make a clear statement what the angle will be. But the neighbours to the Outliers still have the same properties as described in the last paragraphs. For that reason an algorithm that wants to detect outliers should focus on detecting the neighbours of outliers.

In figure 4.2c three adjacent transitions have angles that appear too small compared to its neighbours. None of them are outliers.

4.4.1. Overview of Algorithm

The algorithm to detect outliers based on the angles between transitions involves four steps:

1. Calculate angles
2. Find 3 adjacent angles with small differences
3. Categorize angles
   - To big
   - To small
   - As expected
4. Determine outliers

4.4.2. Calculate Angles

The angle between the points is calculated with the vectors that stretch from the center point to the other points. For each vector the angle between the x axis and the vector is calculated with the atan2 function. The advantage of the atan2 over the conventional arctangent function is that it takes coordinates and returns the angle for the correct quadrant. The difference of the resulting two angles is the desired angle between the points.

When the detected transitions are close to each other, measurement uncertainty can greatly affect the angles at such points. To mitigate that effect the angle for a point is only calculated with transitions that are distant enough.

4.4.3. Find adjacent angles with small differences

Context is important to categorize an angle. Only angles that are as expected do not always require context. This is the case when there are three adjacent angles that fall within a narrow range of each other and create context for the neighbouring angles.

4.4.4. Categorize Angles

The found context leads the way to iterate over every transition and categorize the angle within the context. This is done as described in the decision making diagram in 4.3. Angles are classified into three groups. Angles that are as expected, too big or too small.
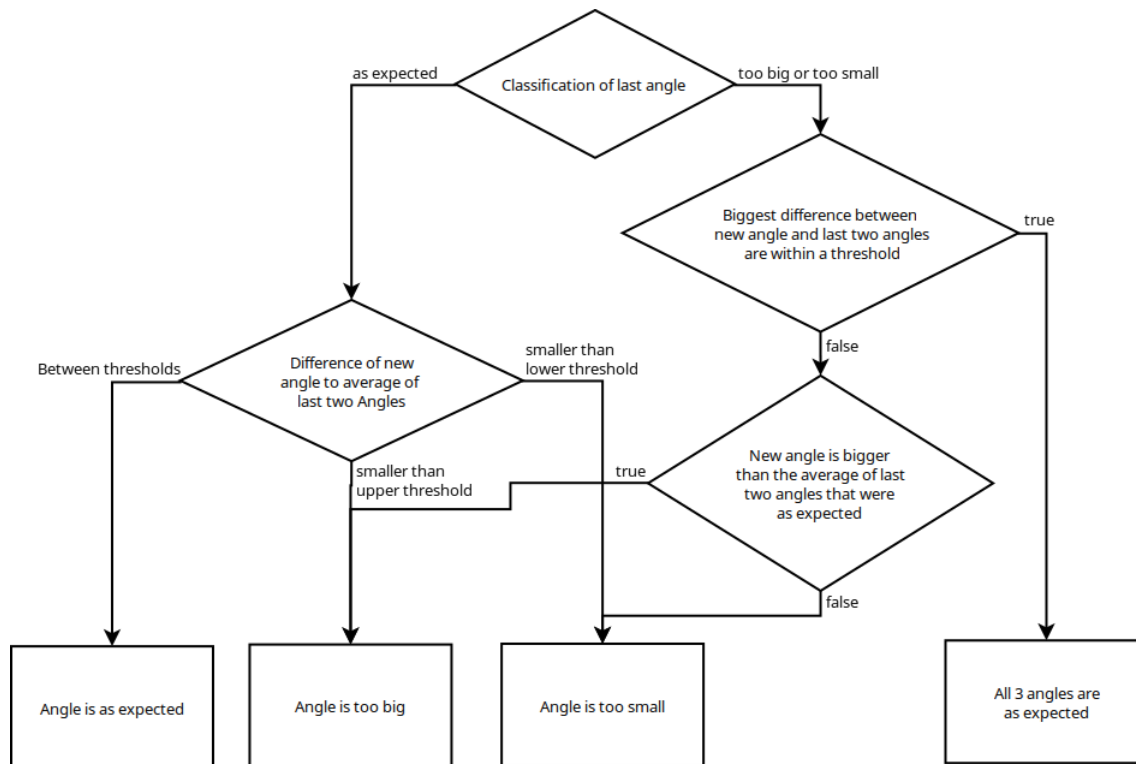
Figure 4.3.: Decision making diagram for categorizing angles

4.4.5. Determine outliers

As described in section 4.4 outliers are surrounded by angles that are not as expected. The categorized angles make that determination straight forward. An outlier is a transition where neither the angle before or after is categorized as expected. The situation described in figure 4.2c where accurate transitions build three adjacent angles that are smaller than expected constitute an exception to this rule. This exception only occurs with adjacent small angles with neighbours that are as expected.

4.4.6. Colour of the Startpoint

The pupil has an uniform colour. So transitions that go from the pupil to the iris start with a colour close to the colour of the startpoint. Transitions from the iris to an eyelid on the other hand start with a colour that is brighter. This correlation can be exploited to improve the number of correctly detected transitions by dividing the score during the filter by the difference to the colour of the startpoint. To avoid a division with zero the absolute difference with an offset is used. Th offset can also be used to control the influence of this part of the algorithm.

4.4.7. Border Detection

The colours of te starburst are represented by the values between one and 255. When a point of the starburst is outside the image it is set to zero. With that it is simple to detect the border during the filter. The behaviour in this case is different depending if there was already a edge or not. If there was already an edge we would like to keep that edge otherwise the result of this ray should be discarded.

To decide if an edge has already ocured a similar method as in section 4.4.8 is used. But instead of adjusting the score of a transitions a hard threshold is applied.

4.4.8. Exploit good Results

The high framerate of the eye-capturing cameras results in small differences of the pupil position between frames. This can be used to improve the result because we already have an idea what the ellipse will look like. The startpoint can be adjusted to be the center ofthe old ellipse so the detected edges will be more equally distributed.

With the old ellipse it is also possible to calculate where a ray would transits this ellipse. This information is used to weight the score of a transition similar as the colour of the startpoint in section was handled. The score is divided by the absolute distance in pixel to the old ellipse on the ray with a small offset.

5. Conclusion / Results

But I must explain to you how all this mistaken idea of denouncing pleasure and praising pain was born and I will give you a complete account of the system, and expound the actual teachings of the great explorer of the truth, the master-builder of human happiness. No one rejects, dislikes, or avoids pleasure itself, because it is pleasure, but because those who do not know how to pursue pleasure rationally encounter consequences that are extremely painful. Nor again is there anyone who loves or pursues or desires to obtain pain of itself, because it is pain, but because occasionally circumstances occur in which toil and pain can procure him some great pleasure. To take a trivial example, which of us ever undertakes laborious physical exercise, except to obtain some advantage from it? But who has any right to find fault with a man who chooses to enjoy a pleasure that has no annoying consequences, or one who avoids a pain that produces no resultant pleasure? On the other hand, we denounce with righteous indignation and dislike men who are so beguiled and demoralized by the charms of pleasure of the moment, so blinded by desire, that they cannot foresee the pain and trouble that are bound to ensue; and equal blame belongs to those who fail in their duty through weakness of will, which is the same as saying through shrinking from toil and pain. These cases are perfectly simple and easy to distinguish. In a free hour, when our power of choice is untrammelled and when nothing prevents our being able to do what we like best, every pleasure is to be welcomed and every pain avoided. But in certain circumstances and owing to the claims of duty or the obligations of business it will frequently occur that pleasures have to be repudiated and annoyances accepted. The wise man therefore always holds in these matters to this principle of selection: he rejects pleasures to secure other greater pleasures, or else he endures pains to avoid worse pains.

But I must explain to you how all this mistaken idea of denouncing pleasure and praising pain was born and I will give you a complete account of the system, and expound the actual teachings of the great explorer of the truth, the master-builder of human happiness. No one rejects, dislikes, or avoids pleasure itself, because it is pleasure, but because those who do not know how to pursue pleasure rationally encounter consequences that are extremely painful. Nor again is there anyone who loves or pursues or desires to obtain pain of itself, because it is pain, but because occasionally circumstances occur in which toil and pain can procure him some great pleasure. To take a trivial example, which of us ever undertakes laborious physical exercise, except to obtain some advantage from it? But who has any right to find fault with a man who chooses to enjoy a pleasure that has no annoying consequences, or one who avoids a pain that produces no resultant pleasure? On the other hand, we denounce with righteous indignation and dislike men who are so beguiled and demoralized by the charms of pleasure of the moment, so blinded by desire, that they cannot foresee the pain and trouble that are bound to ensue; and equal blame belongs to those who fail in their duty through weakness of will, which is the same as saying through shrinking from toil and pain. These cases are perfectly simple and easy to distinguish. In a free hour, when our power of choice is untrammelled and when nothing prevents our being able to do what we like best, every pleasure is to be welcomed and every pain avoided. But in certain circumstances and owing to the claims of duty or the obligations of business it will frequently occur that pleasures have to be repudiated and annoyances accepted. The wise man therefore always holds in these matters to this principle of selection: he rejects pleasures to secure other greater pleasures, or else he endures pains to avoid worse pains.

Declaration of primary authorship

I / We hereby confirm that I / we have written this thesis independently and without using other sources and resources than those specified in the bibliography. All text passages which were not written by me are marked as quotations and provided with the exact indication of its origin.

Place, Date: [Biel/Burgdorf], 07.02.2014

Last Name/s, First Name/s: [Test Peter]   [Müster Rösä]

Signature/s: ....

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List of Figures

List of Tables

APPENDICES

A. Arbitrary Appendix

The European languages are members of the same family. Their separate existence is a myth. For science, music, sport, etc, Europe uses the same vocabulary. The languages only differ in their grammar, their pronunciation and their most common words. Everyone realizes why a new common language would be desirable: one could refuse to pay expensive translators. To achieve this, it would be necessary to have uniform grammar, pronunciation and more common words. If several languages coalesce, the grammar of the resulting language is more simple and regular than that of the individual languages. The new common language will be more simple and regular than the existing European languages. It will be as simple as Occidental; in fact, it will be Occidental.

B. Additional Appendix

B.1. Test 1

To an English person, it will seem like simplified English, as a skeptical Cambridge friend of mine told me what Occidental is. The European languages are members of the same family. Their separate existence is a myth. For science, music, sport, etc, Europe uses the same vocabulary. The languages only differ in their grammar, their pronunciation and their most common words. Everyone realizes why a new common language would be desirable: one could refuse to pay expensive translators. To achieve this, it would be necessary to have uniform grammar, pronunciation and more common words. If several languages coalesce, the grammar of the resulting language is more simple and regular than that of the individual languages. The new common language will be more simple and regular than the existing European languages.

B.1.1. Environment

It will be as simple as Occidental; in fact, it will be Occidental. To an English person, it will seem like simplified English, as a skeptical Cambridge friend of mine told me what Occidental is. The European languages are members of the same family. Their separate existence is a myth. For science, music, sport, etc, Europe uses the same vocabulary. The languages only differ in their grammar, their pronunciation and their most common words. Everyone realizes why a new common language would be desirable: one could refuse to pay expensive translators. To achieve this, it would be necessary to have uniform grammar, pronunciation and more common words.

C. Content of CD-ROM

Content of the enclosed CD-ROM, directory tree, etc.