PHILIPS

TU Delft

Medical 3D visualisation

Designing a better user experience for image-guided surgical planning.

Master Thesis | Design for Interaction | Laura Elise Ruijs | October 2022

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October 2022

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Preface

Dear reader,

I am delighted to present to you my graduation project thesis.

This thesis is the final piece of completing the master Design for Interaction at the Delft University of Technology. Starting my Bachelor of Industrial Design Engineering (TU Delft) in 2014, I always envisioned myself as a physical product designer. Over the years, I have come to realise that my drive and ambition are better suited to digital design. Especially visual communication, UX/UI and graphic design. That is why I was thrilled when this graduation opportunity with Philips came across.

In retrospect, I could not be prouder to present my work, which I could not have completed without the help of a few people.

I want to start by expressing my appreciation to Philips for giving me this opportunity and assisting in developing the graduation project's topic into a project I could combine with my passion for visualisation and graphic design. I can definitely say that I have learned a lot, and I would not have wanted to miss this opportunity to learn about healthcare design.

Thank you, Jon, for supporting me throughout the project, teaching me about UX implementation in medical design and always asking the right questions to trigger my thoughts. Thank you, Judith, for guiding me throughout the project and showing me new perspectives.

Additionally, I would like to thank my entire supervisory team for their infinite patience. Some hiccups during the process caused some delays that felt endless for me. But talking to you gave me my confidence back and the drive to proceed with the process.

Finally, I am tremendously grateful for all the people close to me. Thanks to my family for always having a full fridge I could raid. I am blessed with my friends, who were always there for me, providing honest feedback, brainstorming, or just listening over a glass of wine.

Thanks to everyone who helped me to get the most out of my graduation project.

Enjoy reading!
Laura Ruijs

List of abbreviations

2D	Two-dimensional
3D	Three-dimensional
AI	Artificial Intelligence
CAD	Computer Aided Detection and/or Diagnosis
CT	Computer Tomography
DFI	Design for Interaction (master)
DLS	Design Language System
e/MTIC	Eindhoven MedTech Innovation Centre
IGT	Image Guided Therapy
ISP	IntelliSpace Portal
MPR	Multiplanar Reconstruction
TU/e	Eindhoven University of Technology
TUD	Delft University of Technology
UI	User Interface
UX	User Experience

Computer Aided Detection and/or Diagnosis
Computer system that assists the detection and diagnosis for medical purposes.

Eindhoven MedTech Innovation Centre
Research collaboration between the Catharina Hospital Eindhoven, Maxima Medical Center, Eindhoven University of Technology and Royal Philips Eindhoven.

Image Guided Therapy
Using medical imaging to plan, perform and evaluate surgical procedures.

Design Language System
The Design Language System is a guideline on the corporate identity across all products: digital, physical products and services.

Executive summary

Pancreatic cancer is one of the deadliest types of cancer and generally has a 5-year survival rate of 5%. Surgery (pancreatoduodenectomy) is the only form of curative treatment for patients diagnosed with pancreatic cancer. If the tumour is operable, the resectability of the tumour depends on the level of tumour-vessel contact. Based on CT scans, the assessment of the resectability of the tumour can be critical and demands expertise.

Philips, collaborating with Catharina Hospital Eindhoven and Eindhoven University of Technology (TU/e), has an oncology team called Eindhoven MedTech Innovation Centre (e/MTIC), working on a health care innovation regarding Pancreatic cancer enabled by AI (artificial intelligence) and Medical Image Guiding. This graduation project focuses on this pancreas use case; an integrated imaging workstation is being developed using 3D visualisation and enabling AI to enhance the workflow.

This graduation project focuses on improving healthcare professionals' user experience and interaction within an integrated imaging workstation. The project focuses on visually communicating tumour detection and vascular segmentation, resulting in better diagnosis and surgical planning. The aim is to eventually design a visual language (a design language system guideline) to improve the workflow and experience.

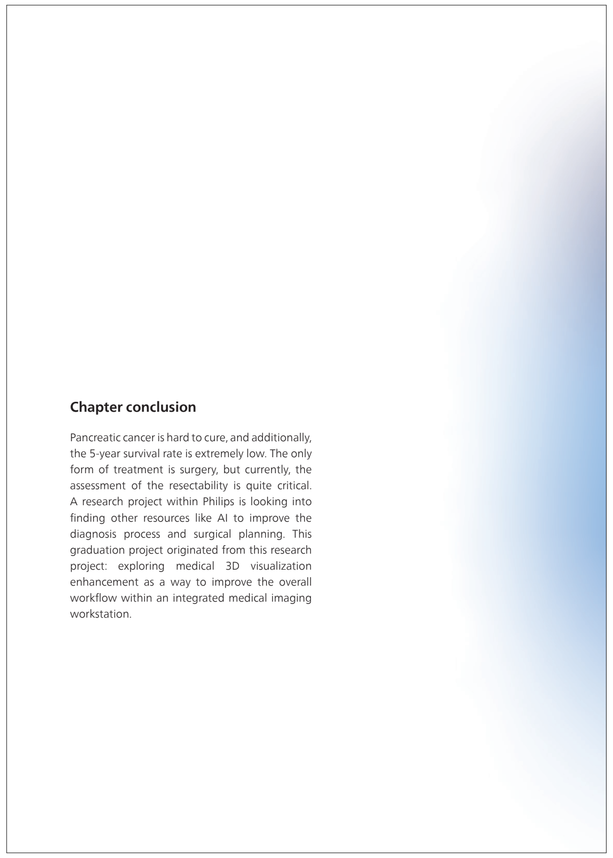
A user review was conducted using videos of user tests performed previously in the pancreas use case. This review led to the usability problems and the user needs of the 3D model in the pancreatic use case. A professional critical study was also conducted, revealing the prototype's strengths and weaknesses.

Eventually, a redesign for the 3D model was developed. This model is focused on showing resectability to improve the workflow. Moreover, uncertainty regarding the tumour size and shape is visualised as well.

Additionally, a DLS guideline for similar applications within Philips focused on medical 3D visualisation was designed at the end of this thesis.

Finally, 3D visualisation, enabled by AI, improves the workflow within a medical imaging workstation.

Reading guide



Cover page
The chapter number and title can be found on the cover page.

On the bottom of the cover page of some chapters, an extra visual can be found. Some chapters (II and III, IV and V) are a whole together. The visual shows some in-depth information about what exactly is documented in the concerning chapter.

Intro chapter
This alinea describes the content of the chapter, every chapter starts with an introduction.

The visual of the double-diamond design process model indicates the part of the process the current chapter is about. For an explanation on the process model, see figure 03 in chapter I.

Chapter conclusion
Every chapter end with an conclusion of the main findings and conclusions.

The in-depth content per chapter can be found between the chapter intro and the conclusion.

Key take-aways
In short the most relevant information from the chapter is listed here.

For a quick read
Find the most important insights, by reading the intro of every chapter followed by the conclusion and key take-aways.

Figure 01: Reading guide

INDEX.

I. Introduction.

This chapter describes the origin and essence of this graduation project's subject. Starting with an introduction to the company Philips, the client and originator of the subject. Furthermore, the explanation of the assignment and elaborated description of the problem is followed by the overall scope of this graduation assignment. Finally, the approach throughout the assignment is explained.

About Philips

Philips, a (leading) health technology company, focuses on meaningful, innovative solutions for improving and maintaining people's health. Their goal is to improve the lives of over 2 billion people annually by 2030. Including 400 million deprived communities. As a brand technology company, they innovate for people with one consistent belief: 'There's always a way to make life better.'

Philips considers people's health journey as a connected whole. Continuously helping people live healthily, preventing illness and disease, and developing the tools clinicians need for precision diagnosis and personalised treatment. They are aiding patients' recovery at home in the community. Supported by a seamless flow of data. (Philips, 2021)

Quadruple Aim

Philips aims to improve people's lives by leading the health technology market, providing innovative solutions tailored to the needs of the consumers and staying ahead of competitors. Therefore, these solutions should be delivered with the quadruple aim; better health care outcomes, improve the patient's experience, improve the clinical staff experience and lower the costs of care eventually.

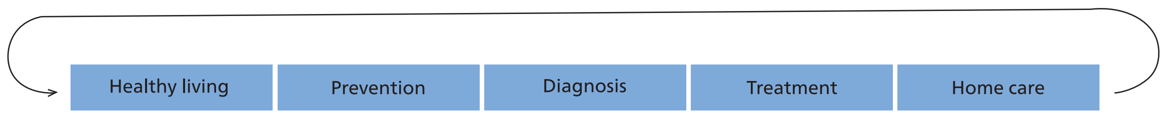


Figure 02: Health journey

Assignment introduction

Pancreatic cancer is one of the deadliest types of cancer and has only a 5-year survival rate of generally 5% (KWF, 2022). Surgery (pancreatoduodenectomy) is the only form of curative treatment for patients diagnosed with pancreatic cancer. The assessment of the resectability of the tumour, based on Computed tomography scans, can be critical and demands expertise.

Philips, collaborating with Catharina Hospital Eindhoven and Eindhoven University of Technology (TU/e), has an oncology team called Eindhoven MedTech Innovation Centre (e/MTIC), working on health care innovations regarding Pancreatic cancer and Lung cancer enabled by AI (artificial intelligence) and Medical Image Guiding. Within the pancreas use case, an integrated imaging workstation is being developed using 3D visualisation and enabling AI to enhance the workflow. A more elaborated explanation of the integrated imaging workstation can be found in chapter II.

This graduation project concentrates on improving healthcare professionals' user experience and interaction within an integrated imaging workstation. The project focuses on visually communicating tumour detection and vascular segmentation, resulting in better diagnosis and surgical planning. The aim is to design a visual language (a design language system guideline) to improve the workflow and experience.

The stakeholders in this context are mainly the healthcare professionals (primarily radiologists and surgeons, secondarily: pathologists, gastroenterologists and oncologists) and eventually the patients.

This project aims to visualise interactions within an integrated medical imaging workstation enabled by AI (Computed Tomography, 3D rendering within a holographic display and quantification panel). And ultimately, develop a design language system guideline (DLS) specifically for other/similar (healthcare) projects within the company. Conclusively, Philips will be able to improve its design solutions and innovations in the healthcare industry.

e/MTIC
Eindhoven MedTech Innovation Center

Scope
Considering the assessment of a tumour/vessel contact in medical imaging is quite challenging and, consequently, impacts the chance of survival rate of the patients. Therefore, the workflow and experience of the health care professional can improve the patient's odds of survival. Accordingly, I want to focus on enhancing the knowledge of the health care professionals in Medical Image Guidance to improve tumour detection and vascular involvement for better diagnosis and enlarging the chance of survival for patients.

Implementing AI in healthcare solutions has much potential to improve cancer care. However, to integrate AI, the workflow and usability must be optimised through UX/UI design to ensure functionality within clinical practice. Therefore, this project aims to design a better user experience for image-guided surgical planning.

Solution space
Fast, easy and trustworthy interactions across medical images and AI-generated 3D models are the project's aim. Furthermore, enhancing the workflow and user experience within an integrated medical imaging workstation.

A design language system guideline will be developed to enhance the experience and workflow within an Integrated Imaging Workstation. Therefore, this project will explore ways to support the performance of health care professionals through UX and UI implementation.

The current prototype within the pancreas use case (see chapter II) and previously performed user tests with this prototype are the starting point of this project. Analysing the prototype (professional review) and the user tests (user review) will point me in the design direction.

Eventually, there will be two deliverables: (1) a design solution for the pancreas use case, (2) a DLS guideline for 3D visualisation.

Approach

The e/MTIC pancreas project has been running for 1,5 years. A user test has been done involving 14 physicians facilitated by the e/MTIC team. At the start of my project, I started with the insights from those user tests and my expert design review. Moreover, I explored the strengths and weaknesses of the UX and UI- technologies to decide on possible ways to improve the experience of healthcare professionals.

With my explorations, I will visually design the communication with the health care professionals in Philips' integrated imaging workstation, focussing on 3D visualisation, including the interactions and workflow with the model. Therefore, I will work on the next iteration of the prototype for the pancreas use case. Ultimately, I aim to develop a design language system guideline that can be implemented in similar projects or diagnoses in the future.

During this project, I want to use the pancreatic cancer use case as a reference to design a DLS guideline (design language system) for medical (imaging) purposes. Other applications will be reviewed to show the scalability of the relevance of the guideline (specifically ISP and IGT applications with 3D anatomical visualisation using Computer-Aided Detection tools).

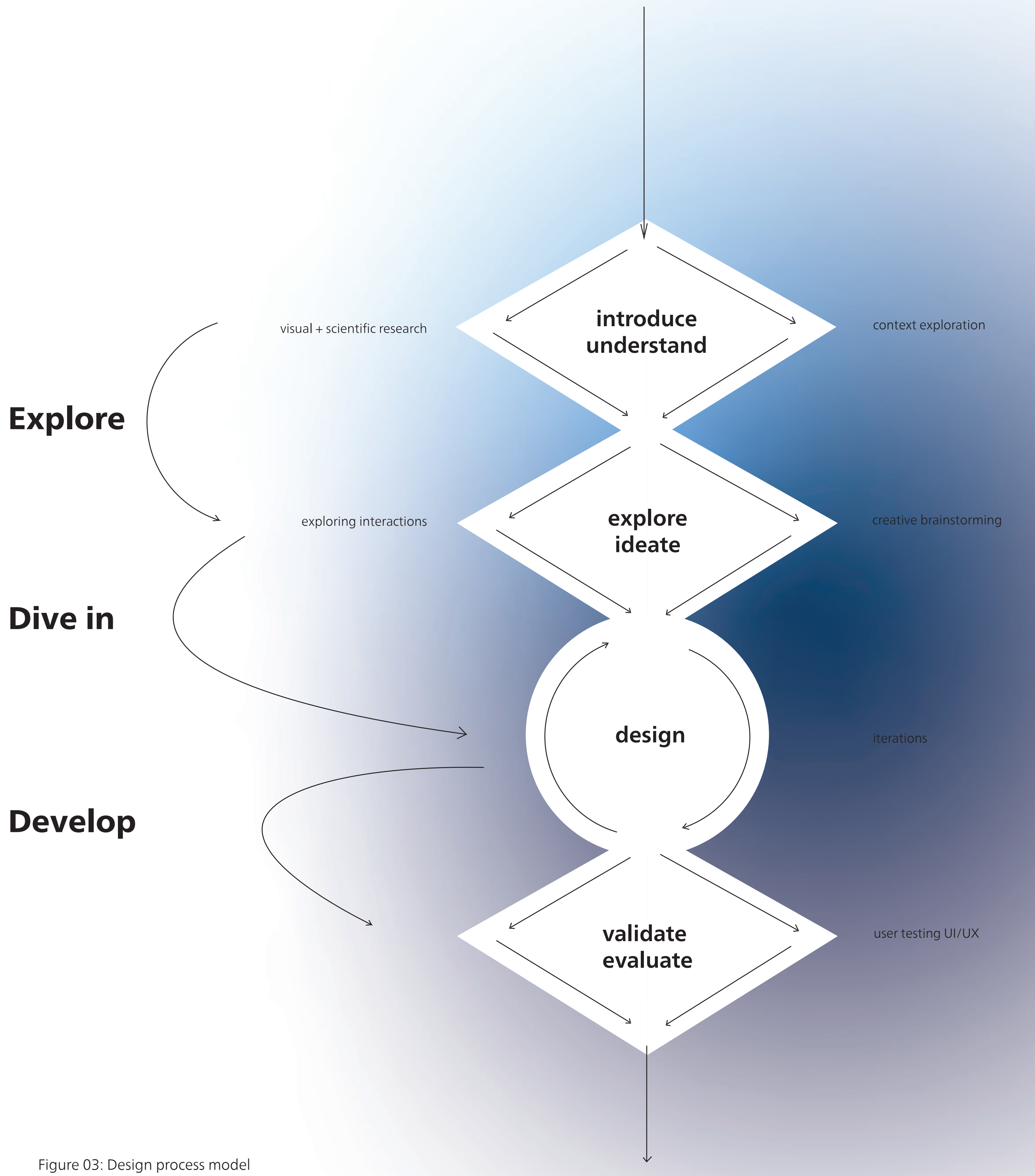


Figure 03: Design process model

Chapter conclusion

Pancreatic cancer is hard to cure, and the 5-year survival rate is extremely low. The assessment of resectability is quite critical since surgery is currently the only form of curative treatment. A research project within Philips is looking into finding other resources like AI to improve the diagnosis process and surgical planning. This graduation project's aim: exploring medical 3D visualisation enhancement to improve the overall workflow within an integrated medical imaging workstation. The final deliverables of this project are a prototype for the pancreas use case and a DLS guideline for medical 3D visualisation.

Key take-aways

Philips *: people's health journey is a connected whole - The* ***assignment aim*** *is to visually enhance the diagnosis- and surgical planning workflow - Scope:* ***assessment vascular involvemen****t - Result: design language system* ***(DLS) guideline*** *and* ***3D model*** *for the pancreas use case.*

II.

Understand.

This chapter contains all the contextual desk research into the problem area and prior solution directions. The chapter starts by describing the anatomical background and the needed knowledge concerning pancreatic cancer, including the current treatments and statistics. This is followed by an overview of the context and literature research on visual perception regarding 3D visualisation and its principles. Additionally, an in-depth analysis was conducted on previous user tests with the current prototype of the research project. The outcome and the user review are an essential foundation of the beginning of this graduation project and resulted in the definition of the usability problems and solution space presented at the end of this chapter.

Research:

literature research | visual review | insights distillation from user tests | application review | personal review

Figure 04: Anatomy abdomen (Terese Winslow LLC, 2022)

Literature research

Pancreas

The pancreas is a retroperitoneal (behind the peritoneum) organ in the upper left of the abdominal cavity, approximately 12 to 15 cm long and about 1-3 cm thick. Surrounded by the stomach, gallbladder, liver, spleen and small intestine (Gray, 2018). The pancreas is located behind the duodenum (the first part of the small intestine), under the stomach and above the small intestine. It consists of three parts: head, body and tail (figure 04). The wider end, located towards the middle of the abdomen, is called the head, the middle part is called the body, and the narrow end is called the tail.

The pancreas is an essential organ since its function is both endocrine and exocrine. (Gray, 2018)

First, the endocrine function of the pancreas is to regulate the blood sugar level. Therefore, the pancreas produces insulin and glucagon, ending up in the bloodstream.
Secondly, the exocrine function plays a vital role in the digestion of food. The pancreas produces digestive enzymes for neutralising gastric acid and digestion in the duodenum.

Pancreatic cancer
In the Netherlands, annually, 1350 people get diagnosed with pancreas cancer, primarily people above 60 years old (IKNL, 2022). And typically, it occurs twice as much among men compared to women. Pancreas cancer is one of the deadliest types of cancer since it is hard to diagnose in an early stage. Furthermore, the 5-year survival rate is less than 5% (figure 06). The most common type of pancreas cancer is in the head of the pancreas (Jaffee, Hruban, Canto & Kern, 2002).

Once diagnosed, there are two possible ways to treat; curative treatment or palliative treatment. Palliative treatment is implemented when curing is no longer an option due to ingrowth in a blood vessel or metastases. This treatment is focused on slowing down the disease progression and reducing pain. Since pancreas cancer is usually discovered in stage 4, when it is already too late to cure, palliative treatment happens often (Jaffee, Hruban, Canto & Kern, 2002).

Possible curative treatments for pancreas cancer are radiotherapy, chemotherapy, coeliac block, endoprostheses or operative treatment (figure 05). The last one is a surgery where the tumour and surrounding tissue is removed. The most common is a Whipple surgery (15-20% of all patients are qualified for this procedure), which is a complex surgery with a high risk of complications (LUMC, 2022).

A Whipple surgery is performed when the tumour is in the head of the pancreas. During this surgery, a part of the pancreas, the first part of the small intestine, the gall bladder, part of the bile duct and the lower part of the stomach are removed. The remaining part of the stomach and bile duct are joined to the small intestine (PCUK, 2022). When the stomach is preserved, it is called PPPD-surgery (Pylorus Preserving Pancreatico Duodenectomy).

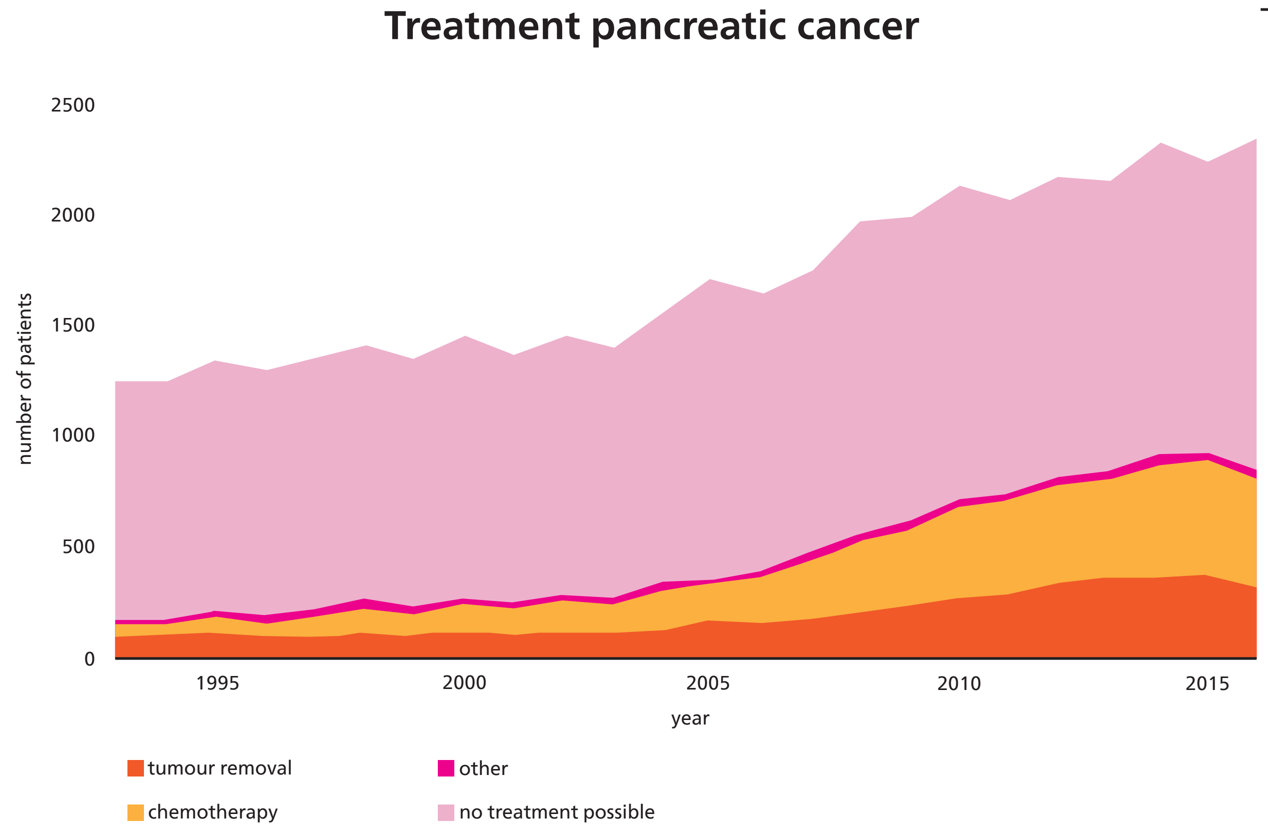


Figure 05: Statistics treatment in the Netherlands (2018) (IKNL, 2022)

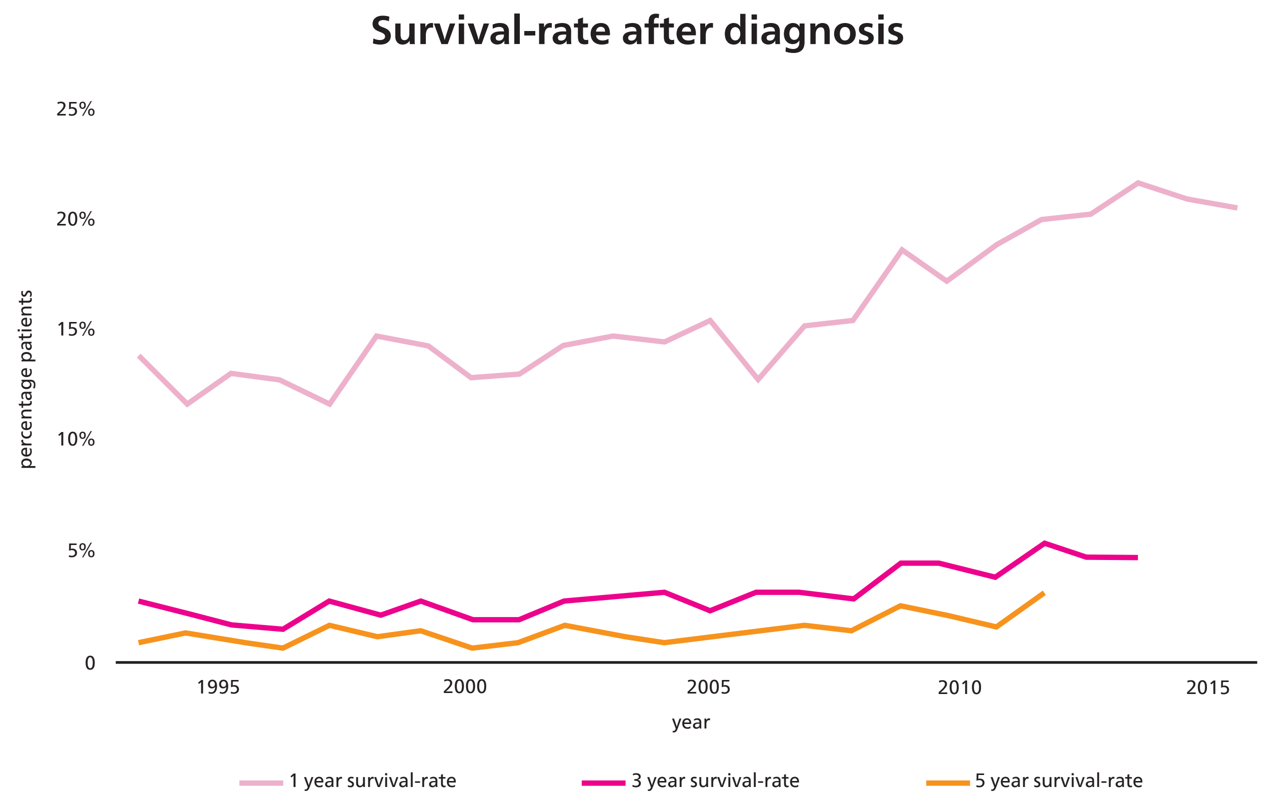


Figure 06: Statistics survival-rate in the Netherlands (2018) (IKNL, 2022)

Figure 07: Pancreatic cancer anatomy

	SMA	Celiac axis	CHA	Portal vein
Resectable	no contact	no contact	no contact	≤90° contact
Borderline resectable	≤90° contact	≤90° contact	≤90° contact	≤90°-270° contact
Irresectable	contact > 90°	contact > 90°	contact > 90°	contact > 270°

*SMA = superior mesenteric artery, CHA = common hepatic artery

Figure 08: Resectability assessment

Resectability

See figure 07 for an anatomical overview of the pancreas, tumour and surrounding vessels that are important for tumour assessment. (Terese Winslow LLC, 2022)

One of the factors in whether a patient can be operated on depends on tumour resectability. There are three levels of resectability: resectable, borderline resectable and irresectable.

The vascular involvement of the tumour is one of the factors that define the level of resectability. No (or almost) vascular involvement means that the tumour is resectable and, therefore, operable. Borderline resectable means that the tumour has vascular contact. Assessment and further analysis will point out whether surgery is possible. When there is too much vascular involvement, possibly even ingrowth, the tumour becomes irresectable (figure 09) (Andersson, Vagianos, & Williamson, 2004).

The CHA (common hepatic artery), SMA (superior mesenteric artery) and celiac axis are arteries and there is the portal vein. As shown in figure 08, the resectability of the tumour depends on vascular involvement regarding these vessels.

Figure 09: Resectability

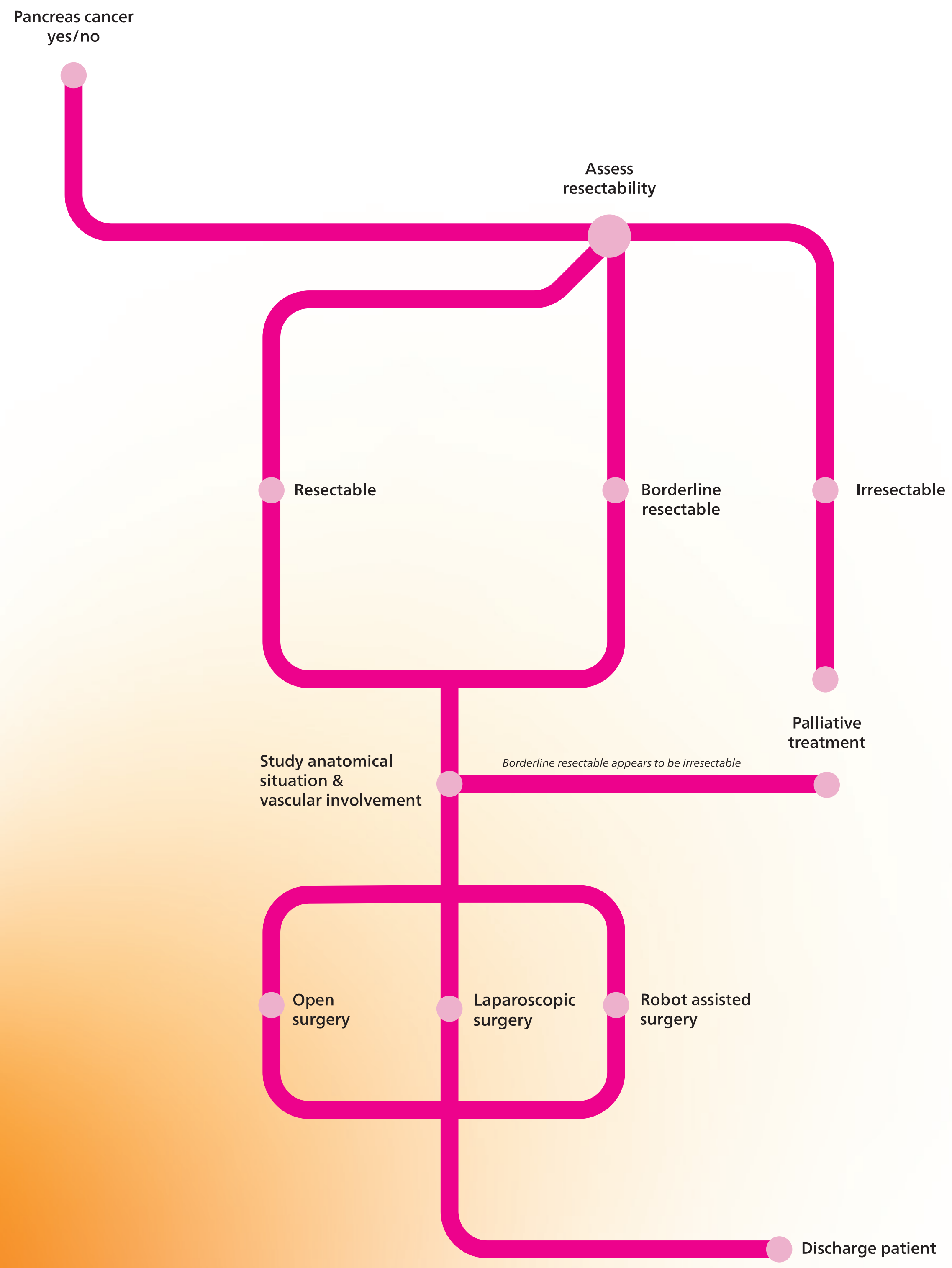


Figure 10: Clinical care pathway pancreatic cancer

Clinical care pathway

In figure 10, an overview of the clinical care pathway regarding the diagnosis of pancreatic cancer is shown, from the first diagnosis step-by-step to the possible treatment. The resectability assessment is a critical part of this flow; according to the tumour-vessel involvement (see also previous page, 'Resectability'), the evaluation is done. The actual footprint of the tumour onto the vessels determines this involvement
(see figure 08 & 09).

Visual perception

Perceiving objects around you or in front of you through the light that enters your eye is visual perception.
Graphical User Interface (GUI) design strictly focuses on triggering the user's senses through vision. Therefore, the user's performance depends on the quality of the information that is shown and how it is shown. A GUI contains all the interactive visual components that hold information and represent actions. These objects change in appearance when the user interacts with them. Examples of GUI elements are icons, buttons, cursors, menus, tabs, toolbars and windows.

The way we perceive information is based on sensory and perceptual effects. Sensory effects are the way one's nerve system and brain process information. More important are the perceptual effects. Visual stimuli like brightness, lightness or colour.

Another perceptual effect related to 3D visual perception is depth. In order to see the distance between objects or between the object and themselves, the user needs depth cues (Lee, Wickens, Liu, & Boyle). The most relevant depth cues for digital 3D visualisation are (figure 11):

Colour: Colour is one of the depth cues for showing 3D and using different shades of the same colour to show perspective. Lambertian shading is a characteristic defining a diffuse reflecting surface. The amount of light a surface receives is related to the angle between the light direction and the surface. The smaller de angle, the lighter the shade of the colour.

Relative size: The foundation of this cue is the knowledge that objects in the front appear more significant than objects in the back.

Reflectance: A depth cue to perceive the roughness of a particular object is reflectance. The more and lighter the reflection on the object, the glossier the object is. The absence of reflections means that the object is matte. Moreover, the reflection of other objects on a surface also tells something about the proportional distance between the objects.

Interposition: Objects in the front block objects behind it.

Light and shading: 3D objects cast shadows and show reflections and therefore reveal their shape, location and distance.

Textural gradients: Changes in colour and texture appear around and object with a textural surface.

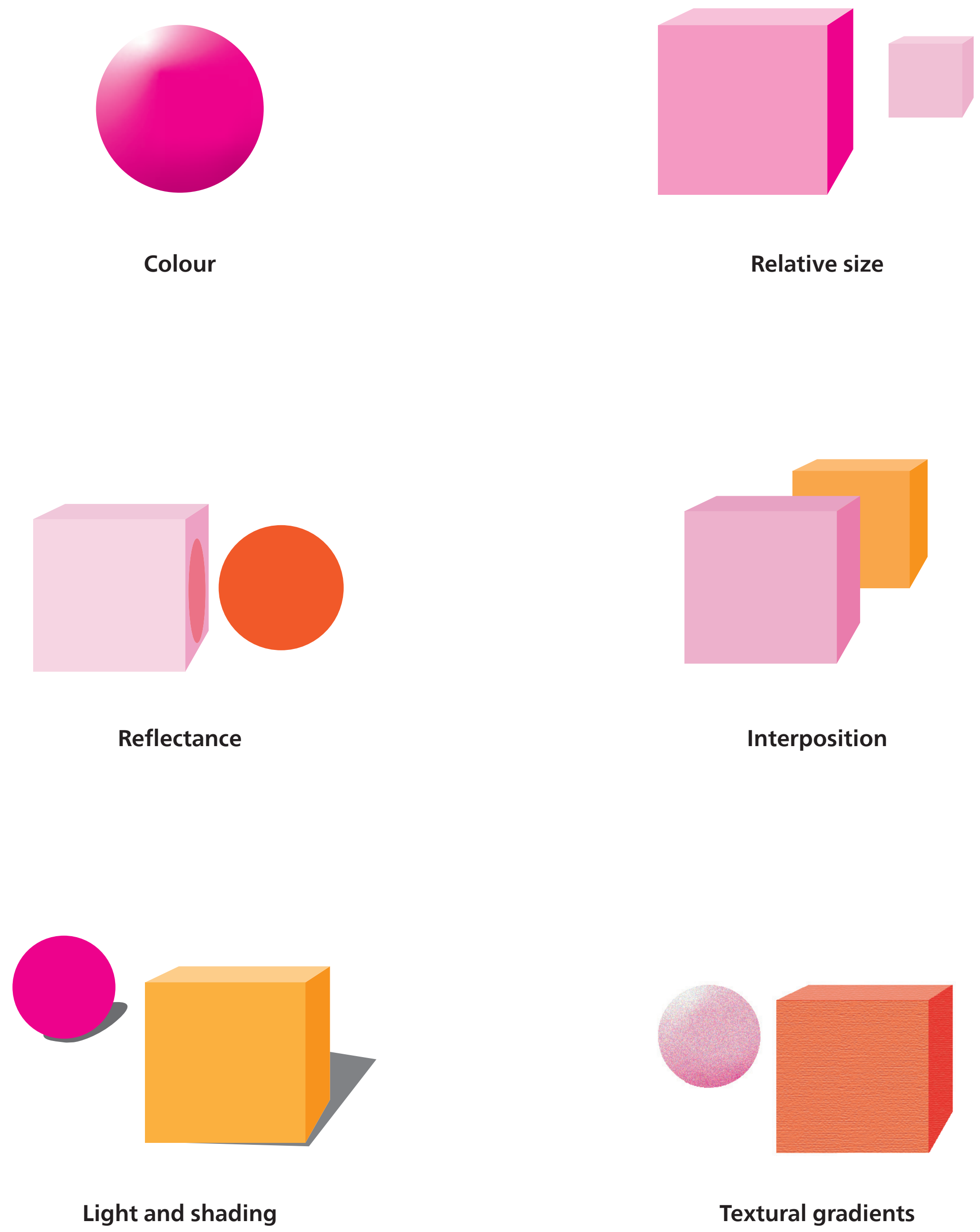


Figure 11: Depth cues for 3D visualisation

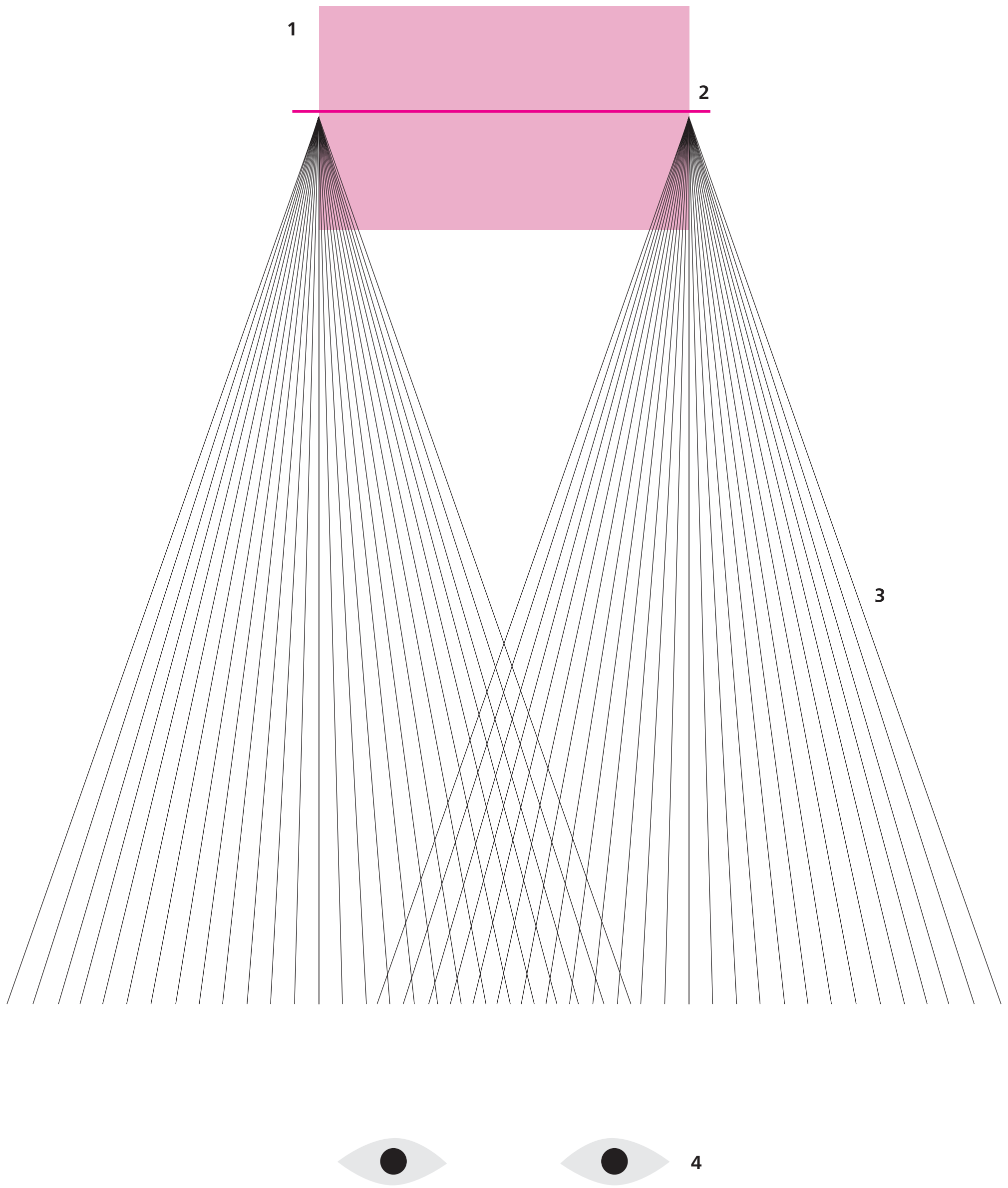


Figure 12: Top view Lookingglass: (1) Lookingglass, (2) zero-paralax plane, (3) viewpoints, (4) user.

3D Visualisation

Every standard (computer/phone/tablet) display is a 2D display. Therefore, the information presented on those screens is also mostly in 2D. Visual information is presented on 2 scales, X and Y, horizontal and vertical, two dimensions. Depth perception can be constructed using simple cues; therefore, some objects might be perceived as three-dimensional on a 2D display.

However, in some cases, there is a need to perceive all of the three dimensions, including depth. Especially when there is an urge to interact with, identify and manipulate the object (Proctor & Zandt, van, 2018). This is feasible on a 3D display.

Lookingglass

Lookingglass is a holographic display using visual illusions of physically presented holograms to enhance a 3D experience. The display is built up out of different planes. In order to produce a holographic effect, the device creates up to 100 views of a certain 3D scene presenting these views over an angle of 50° wide. Which is the view cone of the user. This trick, arranging these viewpoints visually perceives as if the user is seeing an object in 3D. (Looking Glass Factory, 2022)

This is conducted in 2 ways: show different perspectives to each of the user's eyes and change the scene's aspect as the user moves their head around it.

The zero-parallax plane, defined by a red line in the middle of the display, is the depth where objects look sharpest (figure 12). Objects in this plane reside and do not move when the user moves their head around. Objects in front of or beyond the zero-parallax undergo parallax; as the user's head move left, the objects in the front move right, and vice versa. (Looking Glass Factory, 2022)

When looking at the Lookingglass, the user's eyes each perceive multiple views, not just one. Moving their head around, the views blur into each other and therefore results in a fluid cross-fade effect that creates a visual illusion of a 3D object

Colour blindness

Colour blindness (or CVD, colour vision deficiency) affects many people worldwide; approximately 300 million people with CVD. Most of them are men; 1 in 12 men are colourblind. For women, it is 1 in 200 (Clinton Eye associates, 2022).

Generally, there are three types of CVD. The most common is deuteranopia; people with this cannot perceive green colours. In their eyes, blues and yellows stand out. Another rare type is protanopia; these people cannot see the colour red. The third type is scarce and is called tritanopia; people who suffer from this cannot see the blue. For the first two types, these people perceive the world around them in blue and yellowish colours (Colourblindawareness, 2022).

Figure 13, shows a simulation of what people who suffer from colour blindness might see.

Figure 13: Colour blindness simulations (Color oracle, 2022)

User test analysis

During this project, a user test analysis was conducted using (video + audio) recordings from a user test with the prototype performed by eight physicians, facilitated by the e/MTIC team. Those recordings were from a few months before (appendix B).

The test set-up was as follows: the participants individually had to perform simulated preoperative planning for pancreatic cancer user tests in a simulated setting using the integrated medical imaging workstation: containing the CT scans, a CAD-(Computer Aided Detection) generated side panel and a 3D model in a holographic display (figure 15).

Method

During the user test, the participants were instructed to perform preoperative planning as they used to. However, they were to do so in a simulated setting with the prototype of the pancreas use case, shown in figure 15 on the next page. Typically, they perform the diagnosis using CT scans. However, during the user test, an external display showing an anatomical 3D model and a CAD side panel containing measurements regarding the tumour and vascular involvement were added.

For the analysis, a subset (7 participants) of the user test recordings was reviewed at least twice to ensure that all the observations and information were collected. The research was carried out using a prepared template (appendix B). First, every 'task/act' of the participants was marked; again, the participant had no fixed script to follow, just performing preoperative planning like they are used to. Therefore, the 'task' meant the exact action the participant did. When a struggle or error happened during a particular activity, this problem area and its interactions were written down within the template. Per task, a review was done about the severity of the problem area and whether it affected the workflow (figure 14).

All the data collected and additional quotes from the physicians gave a clear overview of the prototype's usability and problems according to the user. In appendix B, the raw data can be found, and a summary of the key findings is presented in figure 16.

Task
Describes the actual act/task the user was performing at that exact moment. For example: the user is scrolling through the CT scans.

Problem area
What problem occurs during a certain task, whats happens and why. Additionally the severity of the problem and the effect on the overall workflow is taken into account. Example: the user does not understand the drawn in annotations and feels like they are blocking his view.

Interaction
The interaction represents the actual interaction the user is doing. Like, using their mouse to scroll.

Ideation
A possible sub-solution, either mentioned by the user or one that already came up while analysing the use-cases.

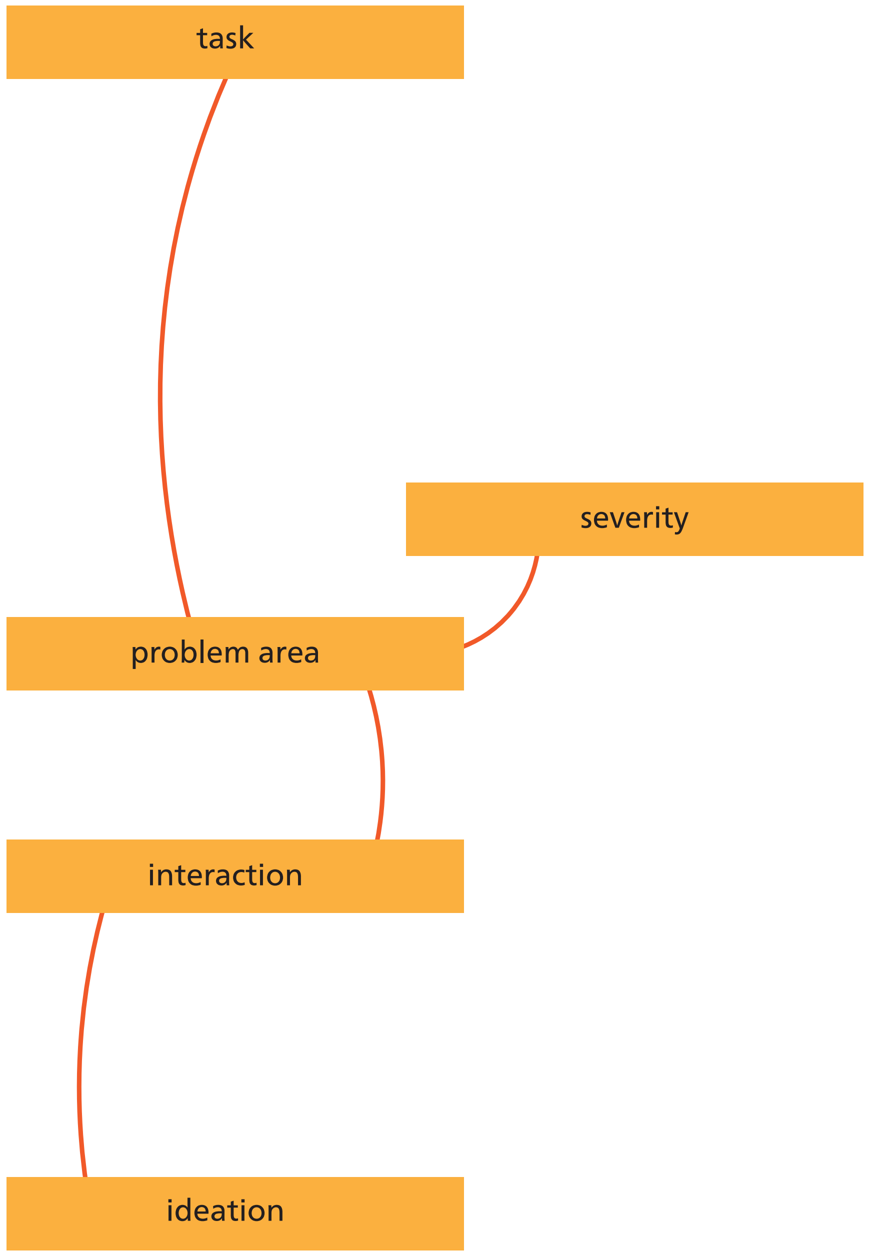
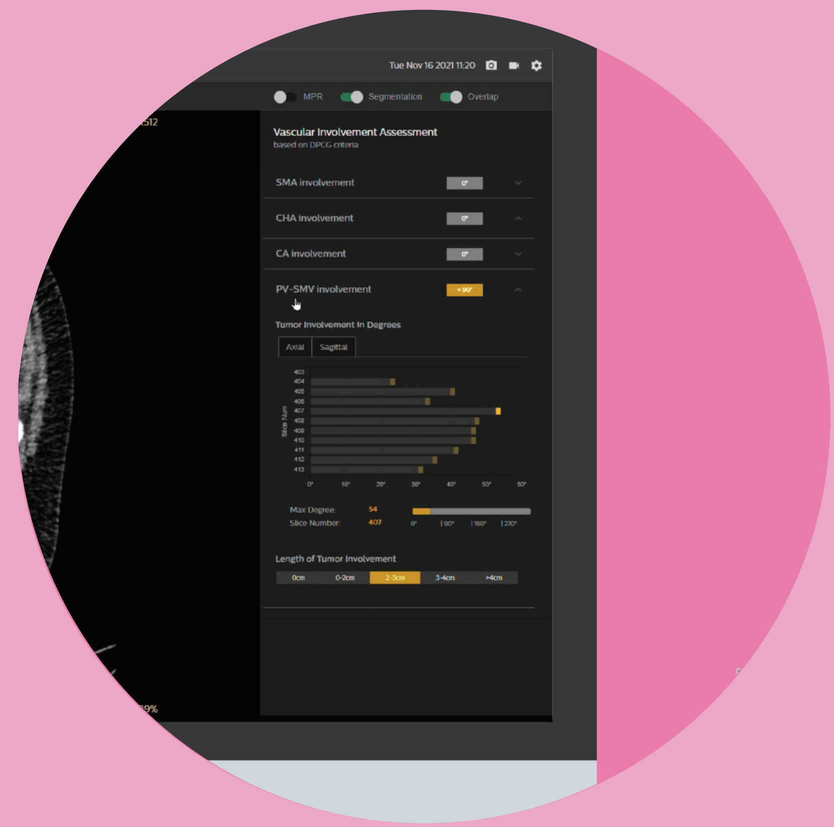


Figure 14: Steps method user test analysis

CT scan
This plane shows the CT scans of the patient. The physician can scroll through all the CT-slices and, therefore, can review the scans. In the current prototype, segmentations are drawn in by a radiologist (as if the user interacts with AI-generated segmentations) to help the user distinguish different structures.



CAD generated side panel
This panel shows the measurements generated by the AI. On top the max. degrees of contact per surrounding vessel. The graph shows the max degrees of contact per CT-slice number. At the bottom an indication of the tumour size.

3D model
Data from the CT scans is used to construct a three-dimensional visual of the tumour and surrounding structures. Therefore, the physician can analyse the tumour from a surgical perspective that is familiar to them.

Figure 15: Test set up of the integrated medical workstation; from left to right: CT scans, CAD generated side panel and 3D model in holographic display.

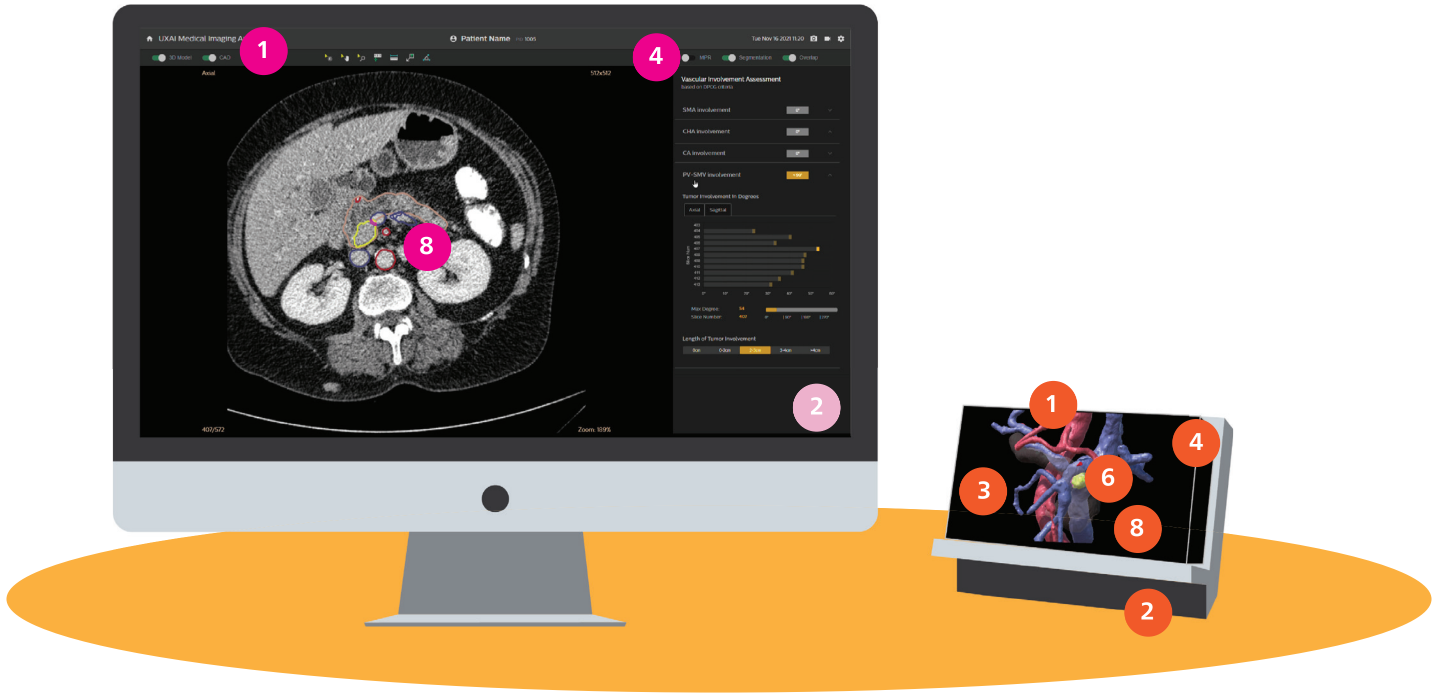


Figure 16: Usability problems in test set-up

Usability problems

During the user test analysis, the following usability problems were found. The topics are categorised per display; CT scan, CAD side panel and 3D model. In figure 16, the usability problems within the design scope are marked within the imaging test set-up.

CT scan

1. Functionalities within the working area are not apparent to the user
2. Measuring tool is not working correctly
3. Slight difference in medical language that is used
4. MPR toggle is hard to find
5. MPR screens are not coherent
6. Correspondence between multiple screens is not clear to the user
7. User questions the correctness of the annotations
8. User dislikes the annotations, it blocks users' view
9. User mentions that he is used to scrolling the other way around
10. User typically never uses a measuring tool
11. User mentions that he wishes to see a cross-section of the footprint

Side panel

1. User mentions that he won't even look at the side panel
2. Functionality of the side panel remains unclear to the user
3. Predefined views are valuable

3D model

1. User doubts the correctness of the blood vessel construction
2. User repeatedly mentions the struggle when navigating in the 3D model
3. Correspondence between annotations and model not immediately clear to the user
4. User mentions that the segmentation rate must be presented
5. User completely forgets about the 3D model
6. Footprint suggests ingrowth instead of contact
7. User only uses the 3D model secondary
8. More surrounding structures should be visible in the 3D model (bile ducts)

Visible is that most usability problems that fit within the design scope occur within the context of the 3D model. Therefore, the main focus for improving the medical imaging workstation will be redesigning the 3D model.

Problem statement cards

The usability problems regarding the 3D model that fit the design scope and were the starting point for this graduation project are listed in figure 17, categorised in content visualisation and focused on the workflow. Every usability problem card shows a rewritten problem statement with an explanation and underlying user needs.

The reason that these usability problems were selected is the rate of the severity of the specific problem and the number of users that experienced this (appendix B).

The cards are categorised into two categories. The first category on the left, content visualisation, is about how certain parts in the design are visualised in a way that affects usability—and focuses on the UI part of the design process. The usability problems concerning the workflow on the right are focused on the UX part of the design process.

Content visualisation

User doubts the correctness of the blood vessel construction (3D model) ●

For the user it is currently not clear whether the outside or the inside of the vessel is visualised in the 3D model. Which actually impacts the workflow and eventually the diagnosis of the clinician a lot. Bumps on the innside of the vessel might be chalk or fat sticked to the vessel. However, bumps on the outside of the vessel indicates that there is a tumour. Therefore, it is very important that it is clear how the vessels are actually constructed.

As a physician I need to ***not be mislead*** *by the* ***design*** *so that I can do a proper diagnoses*

Correspondence between annotations and model not immediately apparent to the user (CT + 3D model) ● ●

In the current design, the use of colour within the CT scan and the 3D model is somewhat coherent. The colour of the annotations within the CT scan match the colours used in the 3D model. This is something that is useful improving the workflow. However, this correspondence is not visible to some of the users and therefore might even hinder the user in an efficient workflow.

As a physician I need to be able to have a ***logic workflow*** *so that I immediately* ***know*** *what I need to do*

Uncertainty must be visualised (3D model) ●

The tumour and vessels are visualised in the 3D model. However, the level of uncertainty is not visualised at all. In order to be able to do a good diagnosis, the physician needs to know the level of vascular contact as well as the origin of the assessment (did an AI do the assessment was it based on the radiologist' opinion).

As a physician I need to know the ***level of uncertainty*** *so that I can do a proper* ***assessment***

Footprint suggests ingrowth instead of contact (3D model) ●

In the 3D model, the footprint of the tumour on the vessel is visualised using a purple/fuchsia solid colour.The fact that 'contact' is visual helps to improve the workflow. However, due to appearance of this visual cue, the footprint indicates that there is ingrowth, not only just contact. Which is a big difference. Therefore, visualising contact must be done in a way that the meaning is clear.

As a physician I need to be able to properly ***interpreted informational output*** *so that I can understand the* ***level of contact*** *(no contact, contact, ingrowth)*

More surrounding structures should be visible in the 3D model (3D model) ●

At this point, the structures that are visible in the 3D model are: pancreas, tumour, aorta, AMS, vena porta, truncus, vena cava, VMI, gastroduodenalis, splenic vein. Some of the users, during user tests, mention that they actually prefer seeing other structures also. According to them this would help them to get a clearer view of the whole image: apart from diagnosis, the tool could additionally be used for extensively surgical planning.

As a physician I need to be able to properly interpreted the ***location of the tumor*** *for better surgical planning*

Workflow

User repeatedly mentions the struggle when navigating in the 3D model (3D model) ● ● ●

The same mouse can be used to interact with the computer screen (with the CT scan and the side panel) as well as the screen with the 3D model. This is quite efficient for the workflow of the user. However, all of the interactions, mouse-actions and keys are hard to recall, which therefore only obstructs the flow of the workflow.

As a physician I need to ***interact*** *with the model* ***smoothly*** *so that I can perceive the addition of the model as '****useful****'*

User only uses the 3D model secondary (3D model) ● ●

During the user tests it was quite striking that some of the users, even though the 3D model is very self-explaining, notable and gives a good overview of the medical situation, did not even look at it in the first place. A reason that might explain this is, is a solid workflow after years of experience (repeating the same steps over and over). Others instantly focussed on the 3D model and compared this with the CT scans.

As a physician I need to be able to ***understand*** *what I am looking at so that I can* ***work*** *as* ***efficient*** *as possible*

Figure 17: Usability problem cards 3D model

Visual review

The analysis conducted on a previously performed user test gave insights regarding the usability problems of the pancreas prototype. Two fundamental design challenges came forward this: uncertainty and footprint. A mood board was created to understand those design challenges better and even start the inspiration and ideation flow early in the process (figure 18 and 19).

Footprint
The other design challenge is linked to the footprint. The footprint is the point of contact (or ingrowth) between the tumour and the vessel. This footprint determines the resectability of the tumour (see 'Resectability', earlier in this chapter).

Overlapping images were the inspiration for this design challenge—high contrast in shape and colours. For assessment imaginable is that a clear demarcation is desired and visualised.

Figure 18: Footprint

Figure 19: Uncertainty

Uncertainty

Uncertainty refers to the level of certainty regarding the tumour size and even the level of certainty for the tumour assessment by the AI. This uncertainty must be visualised, therefore is a significant design challenge.

The inspiration for this mood board is the multiple layers of information captured in the images. Different layers of information refer to the different layers of certainty, or uncertainty, in the visualisation. Additionally, the variation in sharp lines surrounded by blurry gradients, which can be another approach to the different layers. Finally, the high contrast in colours grabs the eye's attention and redirects the flow of viewing the entire mood board.

Chapter conclusion

In conclusion, this chapter explores the subject's context and shapes a concrete scope for this project. First of all, the literature review on visual perception shows what design techniques must be considered for 3D visualisation. A user test analysis builds the foundation of this graduation project by pointing out the pain points within the use of the current prototype. Moreover, it also shows where there is room for improvement and solution space. It is described that the 3D model became the main focus of this project. The analysed usability problems will be of significant use in the next chapter, where further explorations of the 3D model will be described.

Key take-aways

*The **5-year survival rate** of pancreatic cancer is less than **5%** - **Level of tumour/vessel contact** determines the resectability of the tumour - User test analysis led to problem statement carts concerning the current prototype; redesigning the **3D model** is the **focus** of the project.*

III.
Explore.

Research:

literature research | visual review | insights distillation from user tests | application review | personal review

The following chapter contains further explorations related to the pancreas use case' 3D model. These explorations started with a review of other applications within Philips that are alike in medical 3D visualisation. This exploration was done to find similarities in functionalities and differences as a tool for inspiration. Additionally, this analysis was conducted to learn more about the different applications within Philips since one of the deliverables is the development of a DLS guideline for medical 3D visualisation.
Eventually, three relevant applications were found and ultimately used for a creative workshop facilitated for fellow colleagues, resulting in (1) a professional review of the 3D model and (2) a brainstorming session that led to initial ideation.

Figure 20: Applications

Application review

Applications

To explore medical 3D visualisation, other applications within Philips were analysed. In total, five colleagues were interviewed and asked about these applications. Three applications seemed most relevant because of the level of medical 3D visualisation that was very similar compared to the pancreas use case, which are the following applications (figure 20).

Critical review workshop

A workshop session was facilitated to conclude the research phase and kick-start the next step: ideation. This was conducted with 7 participants with different expertise: e.g. usability design, design strategist, design intern, and visual design. The group was divided into two groups, each with its own expertise. The first group contained four participants that excelled in visualisation (UI). The second group's expertise, the other three participants, was the workflow (UX).

This workshop aimed to identify the clinical needs and the need for visual and information harmonisation for the pancreatic cancer prototype and for using 3D models in Philips' products and solutions.

Therefore, during this workshop, the focus was on three other applications containing 3D visualisation. The first half of the workshop aimed to review these three applications critically. The second part of the workshop was a brainstorming session for the pancreas use case using the findings from the first half.

The following three questions were used during the session:

- What is common across all applications?
- Is the need the same?
- Is the solution to fulfil the needs the same?

A template was used to streamline the results within some regions of need: first, the (medical) information and design needs. Secondly, there are the usability indicators. After defining these needs, a clear overview of all the design requirements could be made.

Template
The template (figure 21) used for the creative facilitation workshop was constructed as a matrix-like structure, on the vertical axis, the medical informational needs, and on the horizontal axis, the design directions. The workshop's purpose was to brainstorm about the combination of both on the joints of the grid. This part of the template was carried out by the first group of participants, the ones with visual design expertise.

The other group, however, focused on the bottom half of the template, which consisted of usability indicators like workflow, interactions and tools.

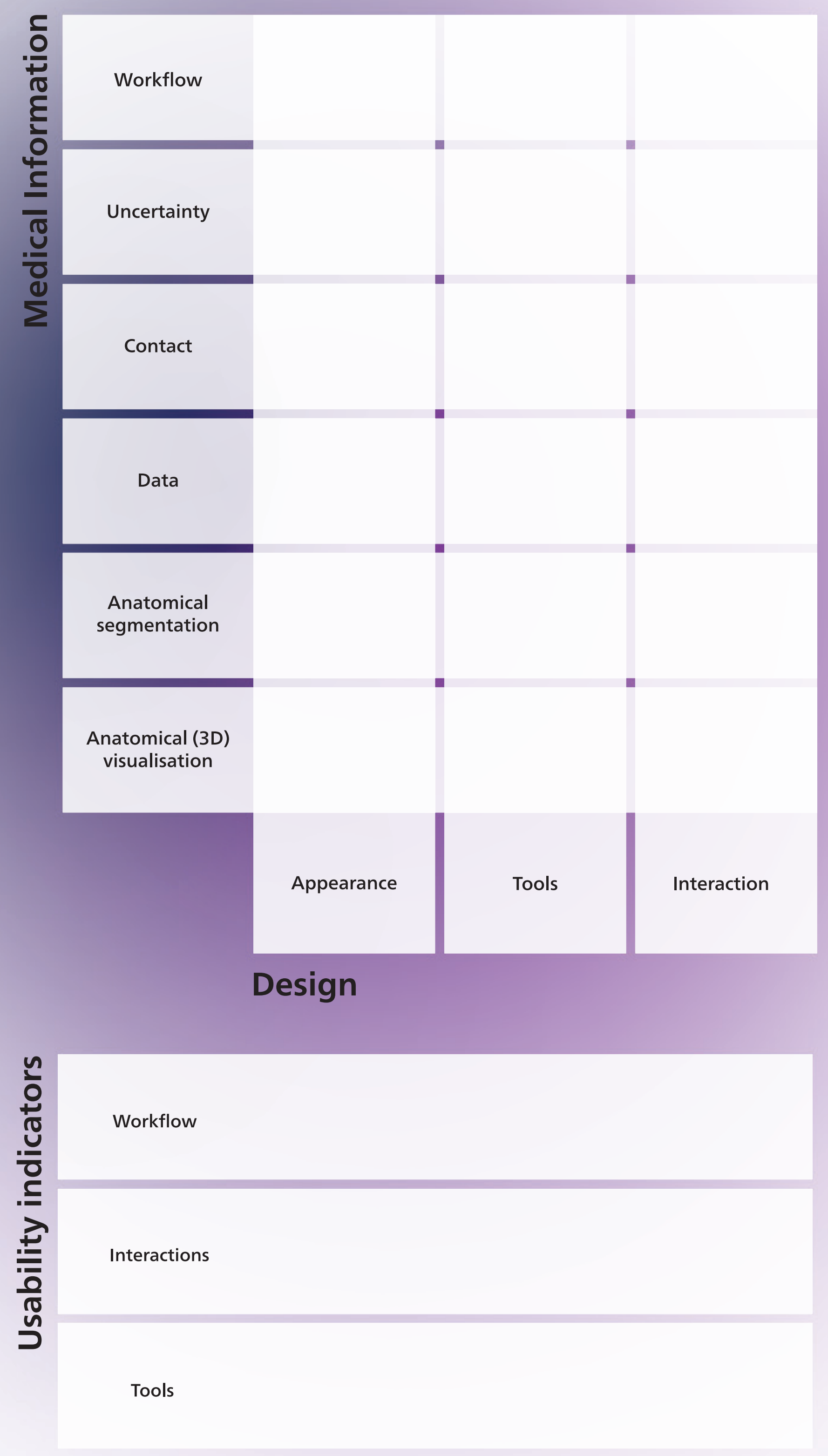


Figure 21: Template workshop

Results

For all the rough data from the creative facilitation workshop, see appendix C. After the workshop, the results were analysed and compared to the usability problems (see chapter II) from the user's review. Eventually, all of the strengths and weaknesses were determined for the pancreas use case' 3D model. These strengths and weaknesses were again clustered in the matrix: design to information needs (figure 22).

Additionally, design opportunities arose from the result analysis as well. These design opportunities were a kickstart for the ideation phase, which is described in the next chapter.

Design opportunities
There is a difference in worst-case segmentation and most certain segmentation.

There is an opportunity to use patterns/meshes in combination with colors.

Opportunity to use slide number indicators to make users aware of uncertainties.

Opportunity to use background as a way to enhance the model.

	Appearance	Tools	Interaction
Workflow	- Used colors are not coherent within multiple screens; between side panel and 3D model/CT scan	- A lot of space is occupied by the side panel	- Workflow different from other applications
Uncertainty	- Level of uncertainty in tumor segmentation is not communicated yet	- It is impossible to change segmentations	
Contact	- The purple footprint is misleading: contact or ingrowth?	- User cannot measure/adapt vascular involvement (2D and 3D)	
Data	- Lack of colour on the side panel		+ Clear and clean data visualisation - Quantifications of contact are only presented on the side panel
Anatomical segmentation	- Solid lines overlap and cover visibility		
Anatomical (3D) visualisation	+ Colors match medical textbook	**- Lack of orientation in 3D**	+ Colors coherent in CT scan and 3D model + 3D depth perception gives more insight

Figure 22: Strengths and weaknesses 3D model

Chapter conclusion

As a further exploration of the pancreas use case' 3D model, three similar applications (containing medical 3D visualisation) were analysed and used for a brainstorming workshop for colleagues, which resulted in a professional review, by designers, of the 3D model. In short, chapter II contains the problem statements resulting from a user's review (8 physicians). In this chapter (III), the strengths and weaknesses were found using a professional review (7 Philips employees), which is a starting point for the ideation phase described in the next chapter.

Key take-aways

*There are other medical **applications** with **similar** properties containing 3D visualisation - reviewing these applications led to an overview of **strengths and weaknesses** of the pancreas prototype - Comparing the different applications gave insight on the **clinical and design needs***

IV.

Ideate.

This chapter contains the ideation process of this graduation project. First, the user requirements came forward from the problem area and the strengths and weaknesses. And these are, together with the design guideline, the overall foundation of the ideation and designing process. The design guideline consists of design needs and considerations, which will be tested at the end of the loop. Finally, the first steps of the ideation phase can be found in this chapter.

Design:

design guidelines | modular set-up | 3D model design process | DLS Guideline | validation

User needs

During this project, many insights were collected, and this information was gathered from different perspectives. First, there was the user test analysis. In other words, the user review, usability problems and pain points regarding the current prototype were assessed and captured in the 'problem area' described in chapter II. Secondly, a professional review was conducted in a critical review during the workshop with colleagues using their different expertise. The results of this workshop were followed by the strength of weaknesses of the pancreas use case. These two sources of information were used as a foundation for the user needs.
In short, problem area + strength & weaknesses = user needs.

The user needs can be found in figure 23. This list will be used as a handheld during the ideation and design process. At the end of the project, the prototype will be tested according to these requirements.very formulated user need is followed by a solution requirement description.

Design

As a user, I cannot be hindered by the appearance of the 3D model so that the outcome of the diagnosis will be interfered with

The appearance of the 3D model must be as clear as possible. Every colour, shape and its meaning must be thought through. Visualisations must not hinder the outcome of the diagnosis. The visualisation of the model must be accurate to prevent wrong interpretations.

As a user, I need to be able to understand the meaning of every colour so that I won't interpret it in the wrong way

First of all, the colours for anatomical visualisation must be chosen according to medical textbook. Therefore, the physicians will know the meaning of most of the colours without explanation. Furthermore, every colour must be used for one purpose only. Overlap in meaning might hinder the workflow or even result in false diagnosis.

As a user, I need to see uncertainty in the 3D model so that I have a complete understanding of the case

In current design, uncertainty is not visualised. There should be a clear way of visualising the distinction between certain and uncertain vascular involvement in the design. Furthermore, this visual aspect will enhance the workflow and understanding of the case throughout the physician's workflow.

As a user, I need to be able to evaluate the level of involvement so that I can have a workflow that is as efficient as possible

The level of vascular involvement plays a big role in determining the outcome of the diagnosis. Considering this, there should be 3 levels of involvement visualised in the design: no vascular involvement, vascular involvement and vascular ingrowth.

Understanding

As a user, I need to be able to make distinctions within the model

Every design decision should be wel thought through, therefore every design decision should have a clear meaning for the the user. Moreover, every aspect within the model should have their own design regulations (e.g. colour, texture, shading, shape).

As a user, I need to be able to see a worst-case and most certain scenario so that I am aware of the uncertainty

In the design there should be a clear visual language to tell the user if the segmentations are 'worst-case' or 'most certain'. Additionally it should be clear to the user who or what the source is of those segmentations; were they drawn in by the radiologist or calculated by the AI?

As a user, I need to know who made the anatomical segmentations (radiologist or AI) so that I know the uncertainty

Anatomical segmentations are drawn in/visualised in the design. However, there should be a visual distinction between segmentations by the AI and the radiologist/physician.

As a user, I need to be able to understand the numerical information that is provided so that I won't make any mistakes during the assessment

The data/output/information is presented in 3 different ways, on 3 different screens/parts of the screen. That is why this information should be presented in a way that the user understands it and additionally can clearly link the concerning information to one another.

Workflow

As a user, I need to be able to understand the visual language so that I won't be misguided

In order to make the workflow as efficient as possible every part of the interface should be clear to the user. Therefore a clear visual language should be used, additionally with use-cues and a guideline for interpretation.

As a user, I need to be able to understand the connections within the medical imaging workstation so that I can work as efficiently as possible

The design consists of three parts; CT scans, CAD side panel and the 3D model. Those three parts together are a whole. Therefore, it must be clear to the user that these screens can be used together instead of separately.

As a user, I want to have the opportunity to correct the AI so that I can correct possible mistakes

Anatomical segmentation drawn in by an AI is not flawless. Therefore the final design should include a tool to able to correct the drawn in segmentations. Additionally, being able to see the different segmentations (by the AI and the radiologist) so that these can be evaluated, presumably even during consultations.

As a user, I need to understand the workspace setup so that I won't interpret or lose time by misunderstanding the displays

The model is designed with its purpose to enhance the physicians' workflow. Therefore the final design must be designed in a way that it will fit seamlessly to the current workflow of the user. Furthermore, another thing that must be taken in account is the different properties of different users (e.g. left/right-handed, colourblindness).

As a user, I need to be able to use the workspace efficiently so that my workflow won't be hindered

The workstation consists of 3 screens in 2 displays. However, the information is distributed over the whole workstation. Therefore, it is highly recommended that the information/tools/visuals have a logical location in the screens to efficiently enhance the overal workflow. Moreover, visually cluster information or certain steps in the workflow.

Figure 23: Requirements 3D model

Design guidelines

As a result of the previous findings of the user review (chapter II), the critical review (chapter III), and the user needs, the following design requirements and considerations were formulated. These requirements focus on what the final design must contain to fulfil the user's needs. At the end of the loop, these requirements are checked for validation.

3D model Pancreas use case

Design requirements

The design of the 3D model should enhance workflow efficiency

The design must visualise uncertainty

The design of the 3D model should fit within Philips' current DLS

The interactions should be simple and easy-to-use

Design considerations

The interactions should reduce inefficiencies within the workflow

The design should enhance trust in AI

DLS Guideline

Design requirements

The DLS Guideline should enhance workflow efficiency

The DLS Guideline should be easy to apply within Philips' applications

The DLS Guideline should fit into Philips' current DLS

The Guideline should have a clear implementable structure

Design considerations

The guideline should contain clear building blocks applicable to all considered applications

The implementation of the Guideline should be efficiently conducted

Modules

The analysis of different medical applications containing 3D visualisation led to the conclusion that all these applications have similarities in functionality and user-application interaction. However, each application differed somewhat in structure and varied in visual properties. Therefore, every application differed in layout and user interactions due to the functionalities and requirements within that use case. That is how the idea of a modular structure was born. This structure will help application developers step-by-step build an application in a fixed format across all applications within Philips (see figure 32-35). This way, every application will have the same look and feel. In short, in this ideation step, developing a modular structure would help me redesign the pancreas 3D model in a step-by-step approach. Properties like side panels and guided workflows were commonalities across the applications and, therefore, a starting point for developing the modular setup. Additionally, this modular structure was the fundamental basis of the DLS Guideline line that was designed.

The application analysis led to a dissection of roughly three layers: medical information, design and workflow. These directions were already used in the template for the creative facilitation workshop in chapter III.

The next step was categorising these layers into clusters of functionality and usability properties, which from now on are called 'segments. Eventually, eighteen of these segments were developed.

These would be distributed over six layers: visual design, presentation, medical information, numerical data, workflow and tools. So, the modular structure contains six layers with each 2 to 5 segments (figure 24).

Metaphorically this modular structure can be seen as building a wall, these layers 'build' from the bottom to the top. Moreover, you'll need the first layer to make the rest. This means that the first layer, 'visual design', is the most critical layer of this modular structure. The following pages further elaborate on the different layers and their segments.

The functionality of these modules is to simplify the design process of designing a 3D medical visualisation application. Per layer must be determined which of the segments are relevant for the concerning application. For an example, see appendix D.

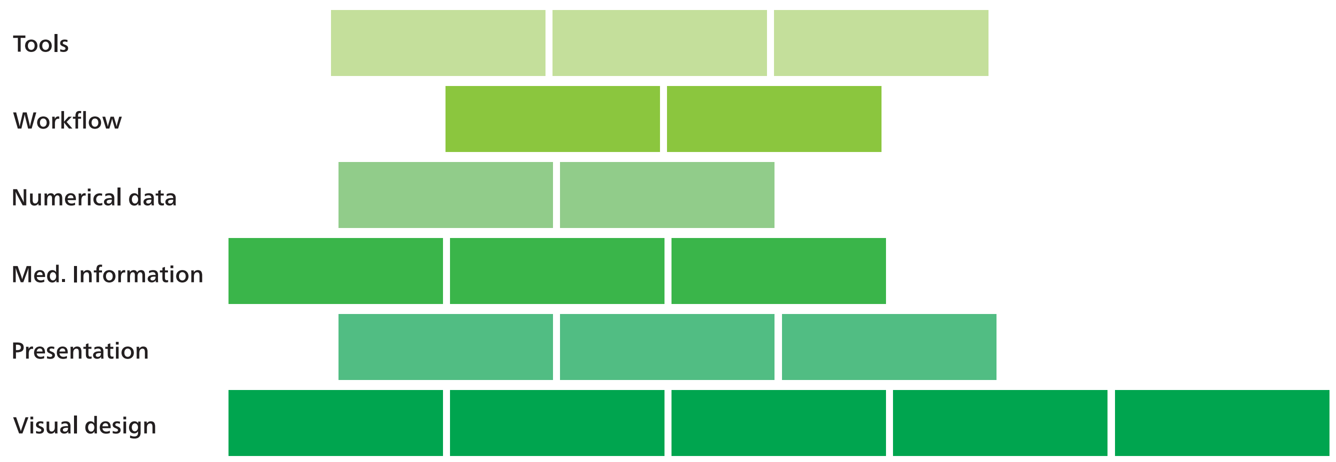
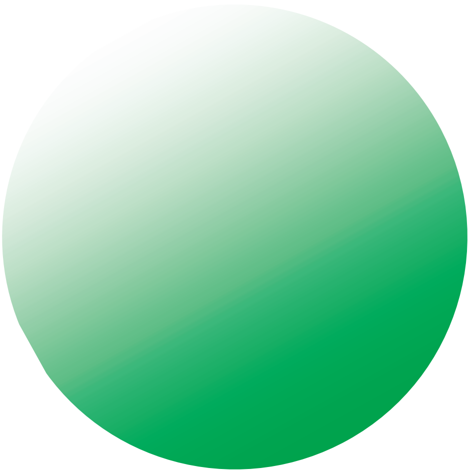


Figure 24: Modulair segments

Visual design

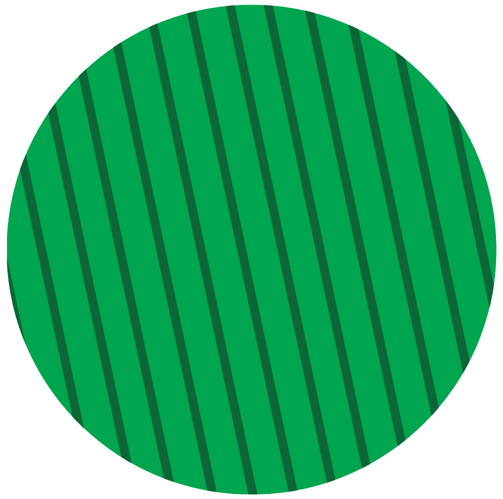
The first layer of the modular structure is ‘visual design’. This is the most important layer concerning visualisation. The segments In this layer are focused on the application’s aesthetics and collaborate with all the other layers.

Colour
Colours are mostly used to indicate anatomical segmentation. However, it became clear that the different applications use other colours for different purposes. It is important that the colours that are being used have a clear meaning and are the same throughout multiple applications.



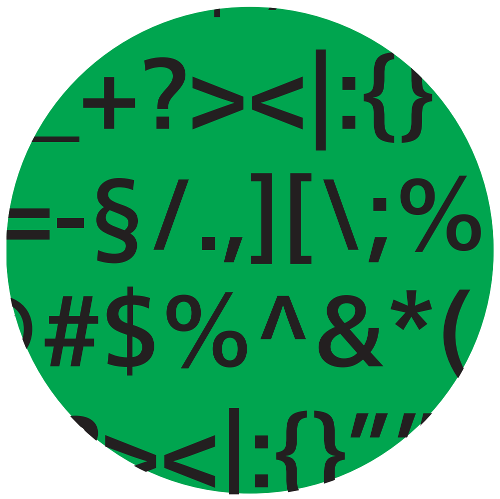
Texture
Patterns or textures add depth and meaning to structures. Therefore, this might give the design more information for the user to grasp.

Figure 25: Design modules



Lining
This block explains the visualisation of the lining used in the design. Lining with different meanings should be visualized differently.

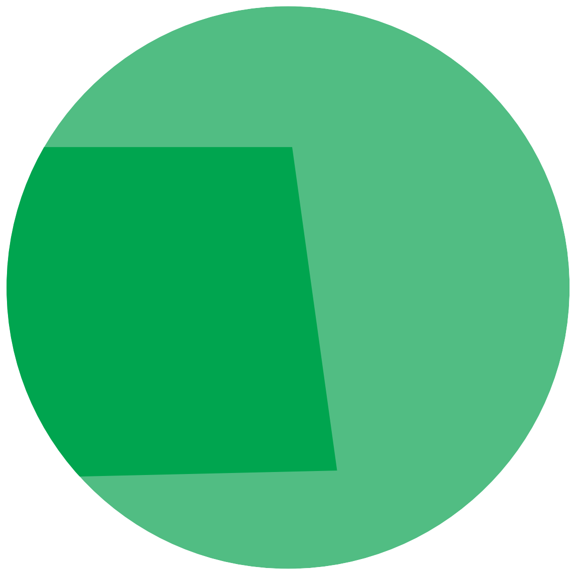
Typography
The font used for the application should be clear and the same for all the applications.



Symbols
In the applications, primarily on buttons, symbols are used to explain functionalities within the design.

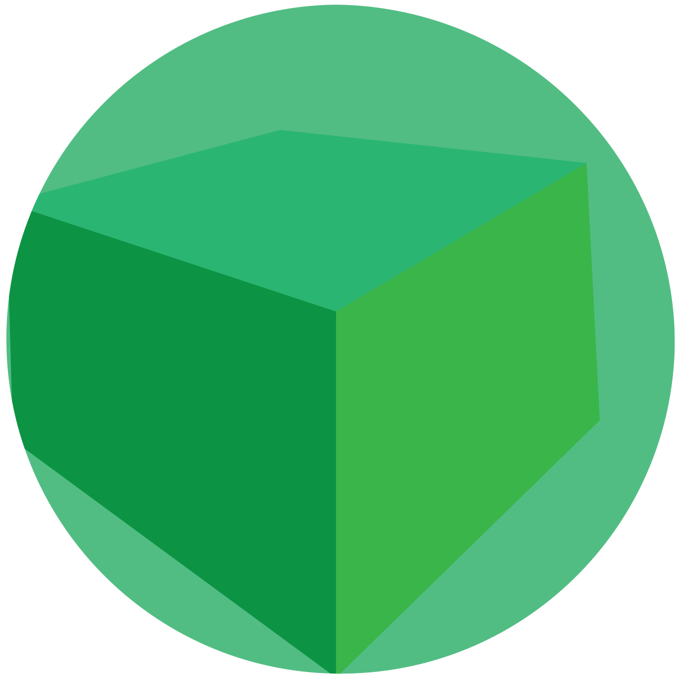
Presentation

The category ‘presentation’ is about the form of visualisation used in the application. In this layer, other than the other layers, only one of the segments is applicable. There is either 2D or 3D visualisation, or both.



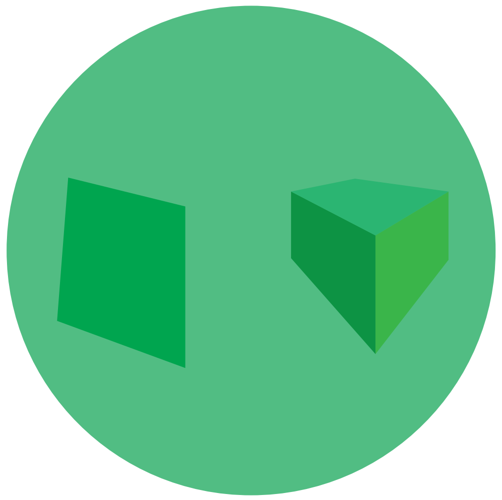
2D on 2D
Strictly 2D, flat visuals are used in the application and presented on a 2D display.

Figure 26: Presentation modules



3D on 3D
Three-dimensional visuals are used in the application and shown on a 3D display.

3D on 2D
This building block refers to 3D visualisation that is presented on a 2D display.



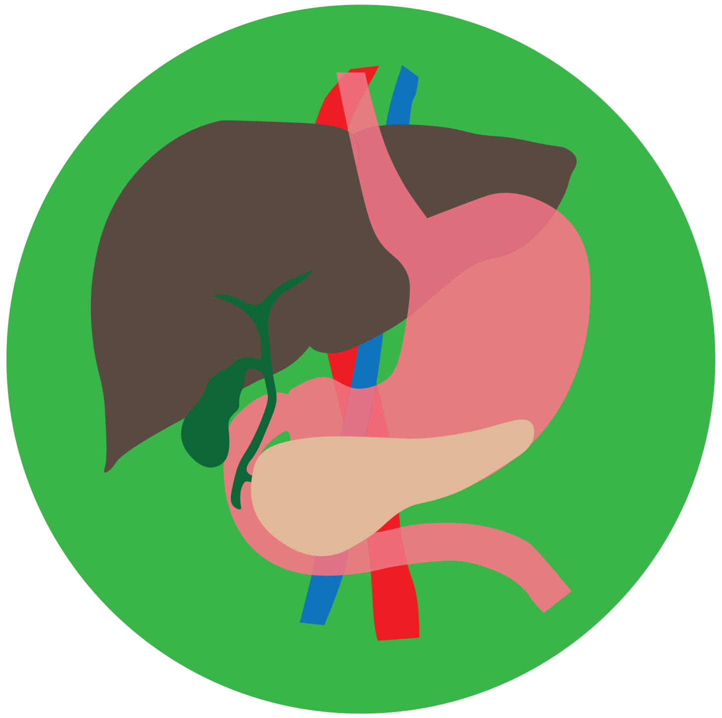
Medical information

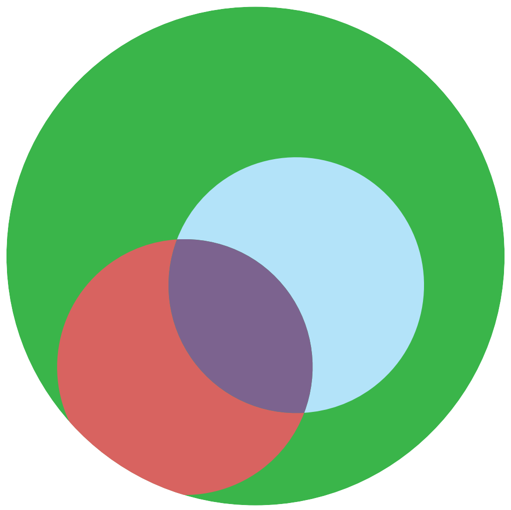
This layer contains the concerning medical information. This differs per application. For example, for the pancreas use case, the segments are uncertainty, contact and segmentation. This layer focuses on what information the physician needs to assess correctly.

Uncertainty
This module can be interpreted in multiple ways. But generally, it is linked to uncertainty within diagnosis or surgical planning. For example, this could mean the tumour size, shape or vascular contact uncertainty. The functionality of this module is to visually give the physician a clear indication of a most certain and worst-case scenario.

Figure 27: Medical information modules

Segmentation
This building block determines how anatomical segmentation within the application must be translated and visualised. Typically, this module is connected to structural segmentation, whether related to AI measurements or drawn in by the physician.





Contact
This specific building block concerns the medical information regarding tumour contact. Typically, the visualisation of vascular contact or ingrowth or tumoral contact with other surrounding structures. This information helps the user to assess the surgical planning.

Numerical data

The ‘numerical data’ layer is focused on the numeric information collaborating with the medical information modules. It contains the actual measurements regarding the anatomical segmentations.

This output is based on the measures within the scans performed by an AI or the physician, e.g., degrees of contact and tumour size.

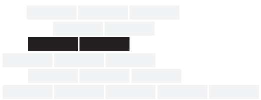
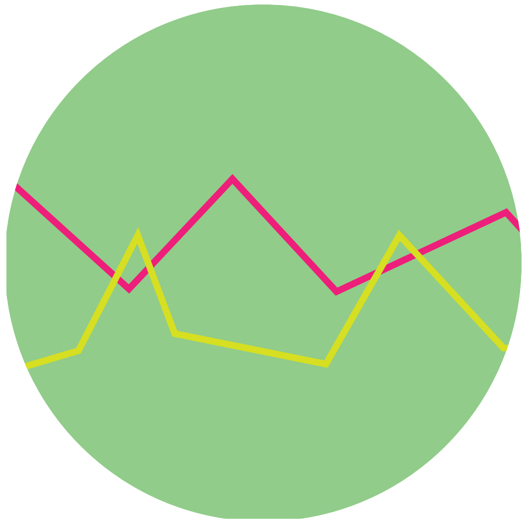


Figure 28: Data modules



Infographic
When visualising the completed measurements, a graph or chart can be used. It is desired that the charts should be clear and readable for the user. Therefore, the infographic should be visualised equally throughout the multiple applications.

AI
This particular module is based on the measurements done by an AI. Is it recommended that this information is labelled separately so the user will know there might be a level of uncertainty. It depends per application whether there this module is applicable.

Workflow

This layer is directed to the interactions within the application and the overall workflow experience. Ideally, the display set-up and workflow are the same for all applications. The application navigation must be straightforward, and the needed interaction must be logical. Additionally, the orientation throughout the whole application must be understandable. Moreover, the user must know what they are looking at.

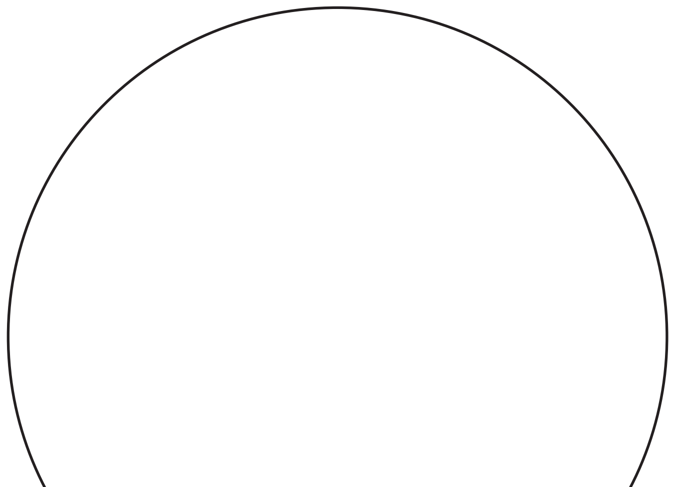
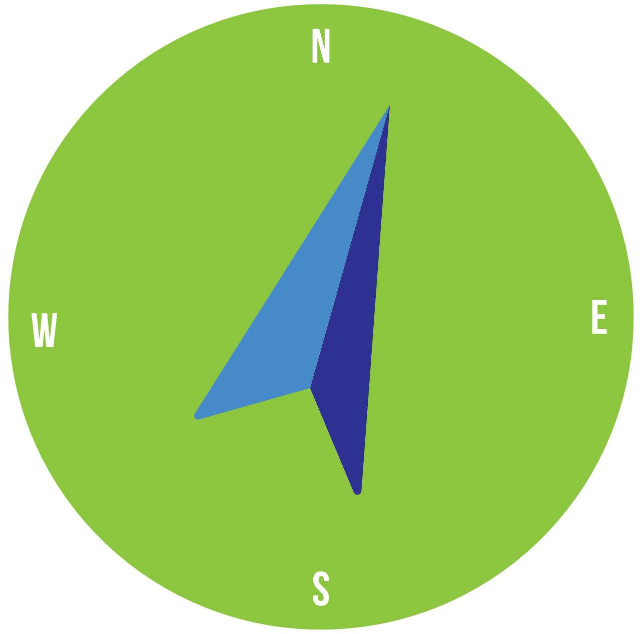


Figure 29: Workflow modules

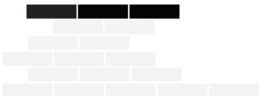
Navigation
Navigation concerns the navigation within the application. This should be upfront and easy to access. Information and visuals should be easy to grasp, and interactions must be logical and accessible. Generally, the workflow should have a clear flow from left to right. Therefore, the functionalities and tools needed through the assessment must be distributed within the workspace accordingly.



Orientation
During the assessment, the user must constantly know where they are in the assessment process and, more important, where the 3D visuals are based compared to the original (CT) scans. Therefore, there must be a way to communicate the orientation of what the user sees at that specific moment.

Tools

The tools or functionalities that access direct interaction with the application conclude the final layer. Not all applications contain tools like this, and therefore this is optional, thus the final layer. Technically, tools are endless, but according to the application analysis (chapter III), the following tools are most common in the reviewed applications.



Measure
Measurements (slightly connected to the data layer) done by either the user or an AI should be visualised in the application. Additionally, there is also a tool to do measurements within the application. For example, measure the tumour size on the CT scan.

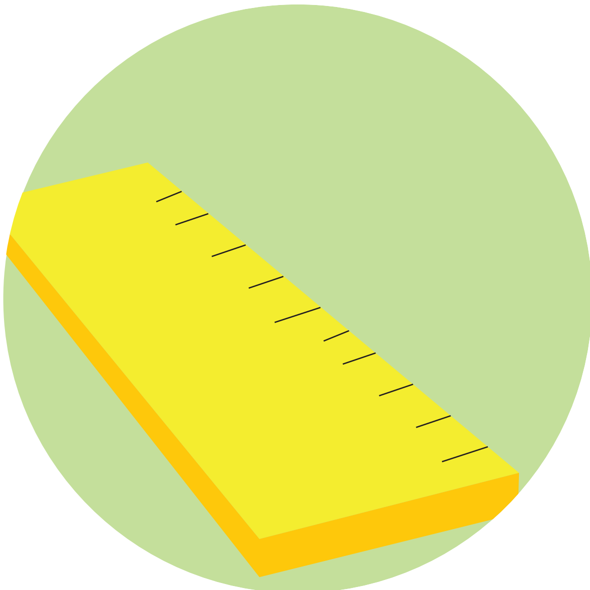


Figure 30: Tool modules

Sketch
Anatomical segmentation (drawn in by a physician or an AI) must be able to be corrected Therefore, a tool to sketch or redraw segmentations is useful.

Review
This module is linked to surgical planning. Within the application, it might be desired to review certain parts of the scenario. For example, drawn in paths for surgically removing a tumour.

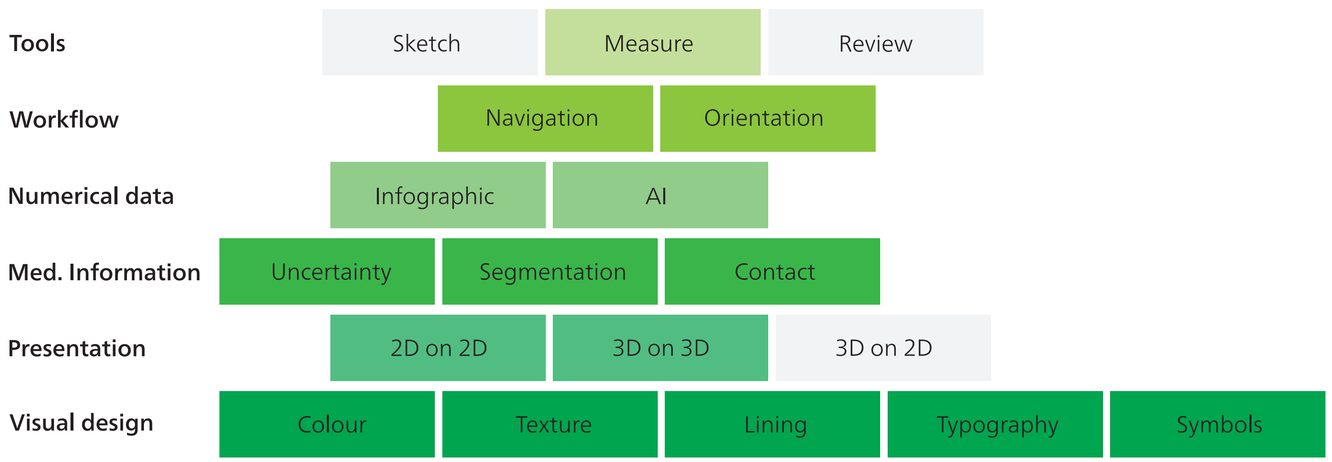


Figure 31: Modules Pancreas use case

Pancreas use case: modular set up

The modules applicable in the pancreas use case are visible in figure 31. For the first layer, design, all modules are used within the application, repeated throughout the other layers. On the first display, 2D visualisation is used in the shape of CT scans and necessary annotations. Another (holographic) display shows a 3D model of the anatomical segmentations.

The relevant medical information for this application is contact, segmentation and uncertainty. Contact is translated into vascular involvement, uncertainty regarding vascular involvement, and tumour size. Anatomical segmentations are visible in the 3D model.

The CAD side panel on the first display shows the information graphs and AI output regarding degrees of contact and the tumour measurements. Moreover, in this application, straightforward navigation is desired since there are many pieces of information that the user needs to identify (CT scans, CAD panel and the 3D model). Simultaneously, some sort of orientation is desired. Finally, sketch and measure tools are also applicable in this use case.

This modular structure is the first step of the ideation phase for (re)designing the 3D model. This structural setup is the approach for the ideation phase. Therefore, each part of the application will be considered and thoroughly reviewed.

The following pages show all the reviewed applications (including the pancreas use case) with their segments and where to find them in the application (figure 32-35).

Chapter conclusion

The reviewed applications (in previous chapter III) led to the conclusion that every application is built and looks different, but across there are roughly some similarities in functionalities and usability. To simplify the construction of those applications, a modular structure was designed containing eighteen segments. These segments are the first step in developing the pancreas 3D model and the DLS Guideline.

Key take-aways

Applications' structure can roughly be divided into 6 layers of information/functionalities: ***design, presentation, medical information, data, workflow*** *and* ***tools*** *- This structure is helpfull for 3D visualising and development of DLS guideline*

V.

Design.

Design:

design guidelines | modular set-up | 3D model design process | DLS Guideline | validation

Chapter V describes the design process of the 3D model (pancreas use case) and the DLS Guideline. The foundation and first ideation can be read in the previous chapter. Concept iterations and the final design can be found in this chapter. First, the 3D model and its explorations are explained, followed by a description of design decisions made for the DLS Guideline. The chapter also contains a colour study and colour blindness validation. In the next chapter, the validation of the concepts according to the user requirements is tested.

3D model
Pancreas use case

Chapter IV describes the foundation of the ideation process for the 3D model. First, the design needs and considerations must be taken into account during the design process. This was followed by a modular setup developed for medical 3D visualisation during this project. These were the first steps of the design process. Appendices C and D show an overview of the modular structure, including some sub-solutions and ideas regarding the 3D model.

The following pages describe the iterative design process of the pancreas use case's 3D model. See appendix E for all the explorations done during this graduation project.

Figure 36 shows the design and iteration process timeline for the 3D model.

Concept directions

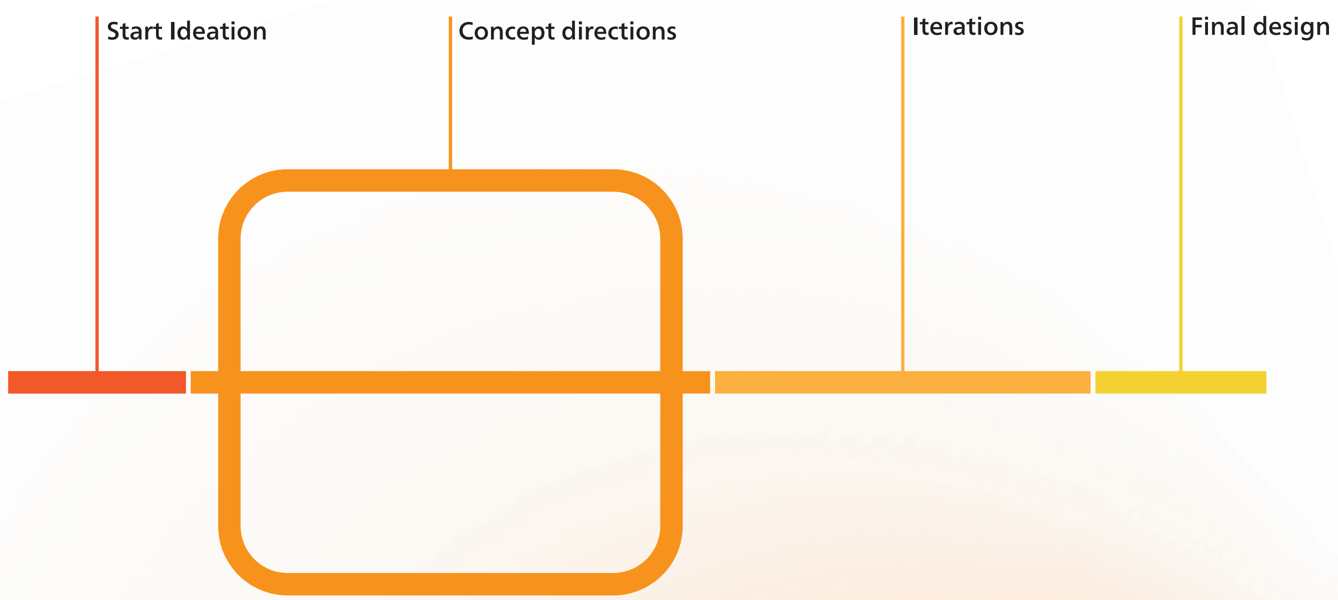
For the design process of the 3D model, three approaches were made. These concept directions are based on the three most relevant user needs (chapter IV).

The difference between 'worst-case' and 'most certain' segmentation should be immediately visible to the user.

Vascular involvement (contact) should be evaluated as quickly as possible.

Connections within the design must be visualised clearly (coherent working space).

These user needs have the most significant priority since they are the most relevant for the user. These three topics were most mentioned during the user review (chapter II) and the professional review (chapter III). Solving these user needs will answer the project's aim to enhance the user experience for image-guide surgical planning. The following pages explain each of the performed concept directions.



Start ideation
The ideation phase started with developing a modular set-up for 3D visualisation (see chapter IV).

Concept directions
As shown, there were some explorations in three separate directions first. These directions were chosen, referring to the problem areas according to the user (see chapter II). These usability problems were prioritised and clustered, resulting in three main design focuses uncertainty, resectability and workflow.

Iterations
These three focuses were explored and finally resulted in one concept. This concept went through several iteration phases, explained on the following pages.

Final design
Finally, a final 3D model was developed for this project. In chapter VI further steps and recommendations for this prototype will be described.

Figure 32: Timeline design process 3D model

DLS Guideline

Healthcare design is rapidly growing, and a lot of new innovative approaches are being explored. One of them is 3D visualisation. For this project explorations and reviews were done for 3D visualisation within the pancreas use case.

Additionally, a DLS guideline explicably for medical 3D visualisation was created in order to provide the gathered explorations in a tangible and applicable format for executing in similar (3D visualisation) applications within Philips.

The foundation and first steps of designing the DLS guideline are described in the previous chapter. The modular structure becomes the structure of the guideline. However, the DLS guideline was developed explicable for 3D visualisation. Therefore, the 'layer' presentation was not included in the guideline.

Additionally, while developing the guideline, it became clear that there was much overlap in information across several layers. Therefore, the guideline was divided into three main categories instead of all the layers (see chapter IV for further explanation). This resulted in a guideline containing three pages: visualisation, medical information (including data layer) and workflow (including tools) (figure 50).

See appendix G for the implementation of the segments on the DLS Guideline.

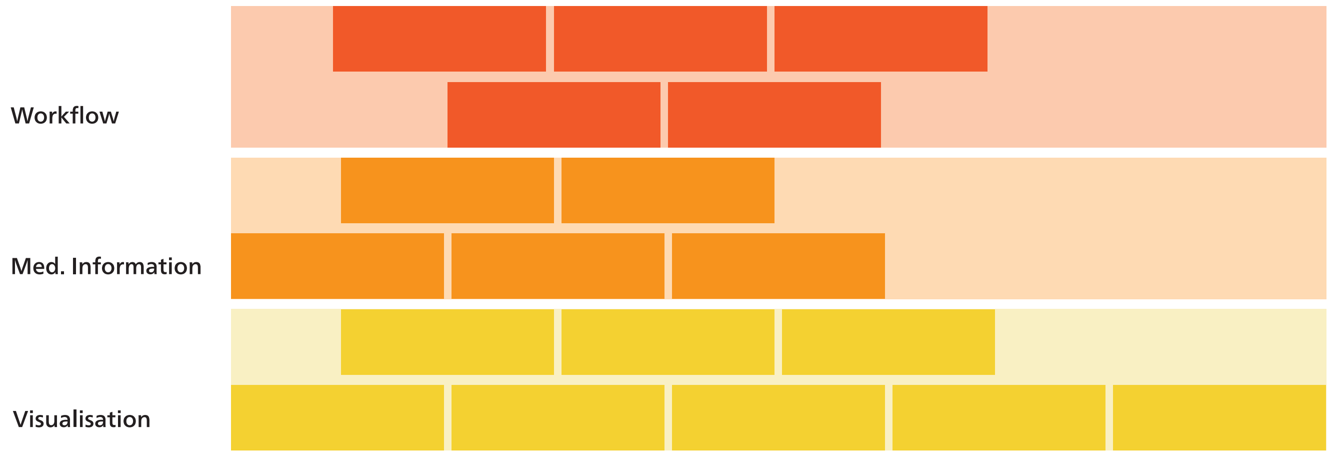


Figure 33: Structural set-up DLS Guideline

Explanation DLS construction

In Philips' current DLS hub (design language system hub), every topic is divided into multiple pages explaining sub-aspects within that topic. Just like the DLS guideline that was developed during this graduation project. The main topic is medical 3D visualisation, divided into three sup-topics or pages: visualisation, medical information and workflow. These pages are constructed using the same structure as Philips' current DLS hub pages.

The page starts with an explanation of the use of the 'topic' in an application. When to use or not to use it, followed by dos and don'ts' regarding the visual representation. The 'structure' explains the distribution of objects, what objects are used and where they can be found in the application. The 'style' and 'layout' shows the sizing and actual location of all the objects within the application. Finally, 'states', if applicable, explains the different forms the application could have and how this will be visualised.

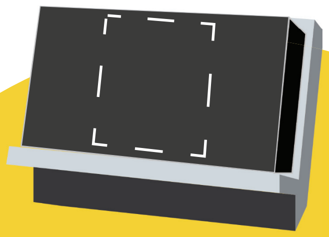
The following pages further explain each page in the DLS guideline.

Visualisation

Chapter IV explains that the topic 'visualisation' comprises five sub-categories: colour, texture, lining, typography and symbols. Since the last two categories are already defined within the DLS hub, these were not included in this guideline. To clarify, the topics included were colour, texture and lining.

Colour
The colours used within the medical 3D application must be according to the medical textbook colours (Gray, 2018). Therefore, every colour has a meaning, which will be the same across all applications. Also, it is essential that the same colour can't be used for different structures. The overall focus of the user will be on the middle of the display; the use of colour should be applied accordingly (also, see medical information).

Texture
The use of texture within the 3D application is to create depth and clarify the model for better diagnosis or surgical planning. For the DLS guideline, meshes are recommended to use. The difference between solid and translucent/meshes adds an extra layer of information about the case (explained further in 'medical information').



Layout
The user's attention must be fixed in the middle of the display. This is where the 3D visualisation is located.

Medical information

This part of the DLS guideline explains the different ways of visualising medical information, e.g., the information that the user needs for diagnosis and surgical planning. Overall, this medical information is divided into two complementary parts: first, the visual information and, secondly, the numeric information, both visible in the application.

Uncertainty
Uncertainty within the 3D model is visualised using a difference in texture. The inner (solid) shows the most certain tumour size. However, this is covered by a mesh structure that indicates the worst-case tumour size and shape. Therefore, the level of contact is determined with the most certain and worst-case visualisation. If applicable, a footprint is visualised accordingly. A separate panel shows the actual tumour size.

Contact
One of the goals of the 3D visual is to make the workflow more efficient. Therefore, optical properties like colour are used to achieve this. In the application, only the structures involved in the diagnosis and surgical planning will have colour (see design). The other structures will be grey and somewhat translucent. This way, all the focus will be drawn. Additionally, the 3D model will have a panel of numeric information, e.g., degrees of tumour-vessel contact.

Layout
The centre of attention is the middle of the display; this is where the user will assess the 3D model. Additionally, on the top right will appear the data panel.

Data
The numeric information is visualised on the CAD panel and in the 3D visual (within the holographic display). Within this data panel, the use of too much information must be avoided. Visually show the most critical data the user needs. Subsequently, the workflow will be as efficient as possible. This panel will be shown in the corner of the display and is additional information to the 3D model.

Workflow

Finally, the workflow explains the navigational properties of the application design. It is desired that all applications have the same structure for a more generalised workflow. In the default setting, the workflow goes from left to right; the option is to customise the display distribution according to the users' wishes. Also, it is required not to overload the user with buttons, panels and text within the application.

Layout
The workflow within the application goes from left to right. The user will find the numeric information on the left of the display in the CAD panel. The rest of the display shows the CT scans. And finally, on the right-hand side, on the holographic display, the 3D model.

Chapter conclusion

This chapter contains the design explorations of the 3D model for the pancreas use case. This is followed by the final prototype. The final design includes 3 different states to show resectability, therefore enhancing the workflow experience. Additionally, uncertainty is visualised in the design using two states of tumour visualisation: most certain and worst-case.

Furthermore, the final design of the DLS guideline was developed as one of this project's deliverables. The guideline is divided into three topics: visualisation, medical information and workflow.

Key take-aways

3D model contains ***three states*** *to show* ***resectability*** *and* ***two states*** *to visualise* **uncertainty***: most certain and worst-case - the DLS* **Guideline** *includes three topics, focussing on medical 3D visualisation:* ***visualisation, medical information and workflow****.*

VI.
Validate

This chapter encloses the conclusion of this thesis. It contains a validation of both prototypes tested to the design requirements formulated at the start of this project (chapter IV). This is followed by limitations and recommendations for further explorations of the concepts.

Design:

design guidelines | modular set-up | 3D model design process | DLS Guideline | validation

Conclusion

This graduation project concentrates on improving healthcare professionals' user experience and interaction within an integrated imaging workstation. The project focuses on visually communicating tumour detection and vascular segmentation, resulting in better diagnosis and surgical planning. The aim is to design a visual language (a design language system guideline) to improve the workflow and experience.

3D model pancreas use case
The first deliverable was to design a 3D model for the pancreas use case. The focus was to communicate tumour detection and vascular segmentation.

The vascular segmentation is visualised using three different states of the 3D model (resectable, borderline resectable and irresectable). Colour coding of the vessel reveals if there is vascular contact or not. Furthermore, two layers of tumour visualisation show uncertainty. The first layer reveals the most certain tumour size and shape, and the second layer reveals the worst-case scenario.

DLS Guideline
The other deliverable of this thesis was to design a DLS guideline. A guideline for 3D medical visualisation for implementation on Philips' applications. Since currently, there is no guideline for 3D visualisation within the DLS hub.

In the end, an interactive DLS guideline, designed within the current visual language of the DLS hub, is developed. This begins with a modular structure to approach the applications' setup, which was used to create the structure of the guideline. The guideline contains three topics: visualisation, medical information and workflow.

Discussion

DLS Guideline

The DLS Guideline should enhance workflow efficiency
One of the topics within the DLS Guideline is focussed on the workflow and describes the overall style and layout for a workflow as efficient as possible.

Ensuring all of the applications have a similar default workflow (from left to right) will simplify the use across multiple applications. Additionally, visuals that support the navigation and orientation within the application are added.

The DLS Guideline should be easy to apply within Philips' applications
The modular structure developed during this project contains 'segments that can be used to build a specific application. The DLS guideline describes the contents of these segments. Therefore, implementing the DLS guideline uses a fixed setup applicable to all applications.

The Guideline should fit into Philips' current DLS
While developing the DLS guideline, the current DLS hub and existing applications were reviewed closely. Therefore, the guideline contains instructions fitting to the current DLS hub. Moreover, the guideline was prototyped in the same template as Philips' DLS hub. Therefore, it looks the same and can immediately be added to de DLS hub.

The Guideline should have a clear, implementable structure
Other applications within Philips (containing 3D visualisation) were reviewed during this project. Based on this review, a modular structure was developed for building 3D applications. Which is the foundation of the DLS guideline that was developed at the end of this project.

Recommendations

DLS Guideline

Test with other applications
The core of this project is focused on the pancreas cancer use case. However, the design can be stress-tested by applying it to similar topics; the lung cancer use case and a few existing software products (specifically ISP and IGT applications with 3D anatomical visualisation using Computer-Aided Detection tools) to show the scalability of relevance.

Tool implementation
Currently, the DLS Guideline contains visuals of examples for the pancreatic use case. To bring the guideline to the next level, visuals of other examples could be added—for example, different functionalities within medical information. The application review (chapter III) revealed that other applications contain other functionalities, workflows, or tools. For example, a tool to draw in lesions or correct them. Another example is visualising medical pathways for surgical planning.

VII. Evaluation

This chapter provides a personal reflection on the assignment, the context, and the process of this graduation project.
Furthermore, reflecting on the personal learning objectives, I formulated at the start of this project.

Assignment and context
In retrospect, I could not have wished for a better environment to conduct my graduation project. Philips has many opportunities and is constantly striving for innovation, which, for me, meant experiencing new experiences and obtaining the opportunity to learn. I enjoyed stepping outside of my comfort zone. Healthcare design is not something I was familiar with or experienced in. However, with some assistance, I could tailor my project to mix my passion for visual design with healthcare design. Hence, I could do a project that was tremendously out of my comfort zone but, on the other hand, felt familiar.

During the project, I felt my potential was acknowledged; therefore, I believed I was granted the freedom to do that, which empowered me. I appreciated that I was given the space to share my thoughts, and others were eager to listen and share their insights with me. It felt pleasant and welcoming.

Laura as a designer
I have always felt that I am more of a doer than a thinker. This project demonstrated this again. The thing I struggled with a lot was the fuzzy front end of the project; this is not something I usually thrive at.

Once again, I learned that I am more of a back end-designer. Nonetheless, I believe that during this project, by doing it, I became more adept at it. I have learned to ask myself the right questions during the process, which helps improve my understanding of what is needed for proper research.

Personal learning objectives

Implementing UX/UI in practice
Learn how to implement UI/UX solutions in practice. I've never experienced applying these techniques in a corporate environment. I have gained some experience with UI/UX design master courses and extracurricular activities; however, never been in a professional environment. I intend to achieve this experience by developing a UX/UI solution by designing a DLS guideline for Medical Imaging Guidance within a professional healthcare environment.

Finalising this thesis, I conclude that I have fulfilled this personal goal since my whole project was about UX/UI design implementation for professional (healthcare) design purposes. This experience showed me that I am more of a UI designer than a UX designer.

Focusing on the tiniest of details, visualising, and making things aesthetically pleasing are things that I thrive on and give me energy. I can also say that I have stepped up my digital prototyping skills in the process and grown a little desire for it. This is something I will proceed to work on, and I may even attempt to incorporate it into my future career.

Work with non-designers
I want to learn to work with non-designers. Moreover, learning how to communicate (my designs, for example) with other (non) designers. During my graduation project at Philips, it is very likely that I will learn how to do that since I'll be working in a professional environment. For me, this means working in a team with other people and other professions, and I think this also means that you can learn a lot from each other.

I believe I have mastered this objective quite well. I worked with several stakeholders and solicited their input on my work. The diverse audience provided me with a wealth of criticism and, therefore, ideas into how I may modify my work to interact with non-designers as well.

Gain experience within a big company
Learn more about the setup and structure of a big company and how innovative technologies are implemented in practice. Doing my graduation project at Philips will probably give insight into this. Achieving this, I might be able to visualise witnessing the whole process of innovation to product realisation from up close during my project at Philips.

Philips' excellent co-workers and business infrastructure provided me with sufficient insight into working for a large organisation. This experience was enhanced by interacting with co-workers, organising meetings/calls, and facilitating workshops. I now have a deeper understanding of how the innovation process is carried out in large organisations.

Practise healthcare design
Getting a better understanding of design for health care purposes. This is also something I don't have much experience with, but I am eager to learn more about this and execute my learnings during this project. First, I would have to get more familiar with health care in general; this will happen during my (literature) research at the beginning of this project. After this, I will start ideating, iterating and user-testing several concepts, which will help me to understand the implementation of design in healthcare solutions (learning by doing).

At the start of this thesis, I had no experience with healthcare design. Philips, being one of the biggest in healthcare design, provided the perfect setting to learn more about this. I enjoyed the chance to work outside of my comfort zone. Not only have I learnt a great deal about healthcare design, but also about implementations that I may apply for other purposes in the future. As an example, developing an AR/VR experience, designing for AI-implemented technologies, and studying and working with future technologies such as holographic/3D design.

VIII.
References

A

Andersson, R., Vagianos, C., & Williamson, R. (2004). Preoperative staging and evaluation of resectability in pancreatic ductal adenocarcinoma. HPB, pp. 5-12.

B

Blandford, A., de Pietro, G., Gallo, L., Gimblett, A., Oladimeji, P., & Thimbleby, H. (2011). Visualisation and Interaction system for Surgical Planning (pag. 70).

Boeijen, van, A. (2020). Delft Design Guide. BIS Publishers.

Brand, W., & Koene, P. (2017). Visual Thinking. BIS Publishers.

C

Clinton Eye associates. (2022, september). Colourblindness. Retrieved from Clinton Eye: https://www.clintoneye.com/color-blindness.html

Color oracle. (2022, september). Color oracle. Retrieved from Color oracle: http://colororacle.org

Colourblindawareness. (2022, september). About colourblindness. Retrieved from Colourblind awareness: https://www.colourblindawareness.org/colour-blindness/

G

Gray, H. (2018). Gray's Anatomy. Sterling Juvenile.

I

IKNL. (2022, july). Statistics. Retrieved from IKNL: https://iknl.nl/nieuws/2018/alvleesklierkanker-heeft-slechtste-overlevingscijf

J

Jaffee, E. M., Hruban, R. H., Canto, M., & Kern, S. E. (2002). Focus on pancreas cancer. In CELL PRESS (Vol. 2).

Jorritsma, W., Cnossen, F., & van Ooijen, P. M. A. (2015). Improving the radiologist-CAD interaction: Designing for appropriate trust. In Clinical Radiology (Vol. 70, Issue 2, pp. 115–122). W.B. Saunders Ltd. https://doi.org/10.1016/j.crad.2014.09.017

K

KWF. (2022, may). Pancreas cancer. Retrieved from KWF: https://www.kwf.nl/kanker/alvleesklierkanker

I. II. III. IV. V. VI. VII. VIII. IX.

L

Lee, J. D., Wickens, C. D., Liu, Y., & Boyle, L. N. (n.d.). Designing for people: An introduction to human factors engineering.

Looking Glass Factory. (2022, june). Key concepts. Retrieved from Looking Glass Factory: https://docs.lookingglassfactory.com/keyconcepts/how-it-works

LUMC. (2022, july). Alvleesklierkop verwijdering Whipple operatie: PPPD (Pylorus Preserving Pancreatico Duodenectomie). Retrieved from LUMC: https://www.lumc.nl/patientenzorg/praktisch/patientenfolders/Alvleesklierkop-verwijdering-whipple-operatie-pppd

P

PCUK. (2022, june). Types of surgery for pancreatic cancer. Retrieved from Pancreatic cancer UK: https://www.pancreaticcancer.org.uk/information/treatments-for-pancreatic-cancer/surgery-for-pancreatic-cancer/whipples-operation-and-other-types-of-surgery/#whipples

Philips. (2022, april). Brand guidelines. Retrieved from Philips our brand: https://www.ourbrand.philips.com/guidelines/#/

Philips. (2022, april). DLS hub. Retrieved from Philips DLS hub: https://share.philips.com/sites/STS20160310160030

Philips. (2022, april). Demo suite. Retrieved from Philips: https://demo-suite.philipsinternal.com/

Philips. (2022, february). About. Retrieved from Philips: https://www.philips.nl/healthcare/about/philips/our-approach

Philips. (2022, march). WHSS procedural automation. Retrieved from Philips: https://web.microsoftstream.com/video/701d371a-21bc-4981-b784c37e6b33f9e3?list=studio

Preim, B., Baer, A., Cunningham, D., Isenberg, T., Ropinski, T., Ropinski Survey, T. A., Maciejewski, R., Ropinski, T., & Vilanova, A. (2016). of Perceptually Motivated 3D

Proctor, R. W., & Zandt, van, T. (2018). Human factors in simple and complex systems. CRC Press.

R

Ristovski, G., Matute, J., Wehrum, T., Harloff, A., Hahn, H. K., & Linsen, L. (2017). Uncertainty visualization for interactive assessment of stenotic regions in vascular structures. Computers and Graphics (Pergamon), 69, 116–130. https://doi.org/10.1016/j.cag.2017.10.002

S

Stappers, P., & Sanders, E. (2012). Convival Toolbox. BIS Publishers BV.

T

Terese Winslow LLC. (2022, february). Medical And Scientific Illustration. Retrieved from Terese Winslow LLC, Medical And Scientific Illustration: https://www.teresewinslow.com

Tummala, P., Junaidi, O., & Agarwal, B. (2011). Imaging of pancreatic cancer: An overview. Journal of Gastrointestinal Oncology, 2(3), 168–174. https://doi.org/10.3978/j.issn.2078-6891.2011.036

V

Visualization of Medical Image Data. Computer Graphics Forum, 35(3), 501–525. https://doi.org/10.1111/cgf.12927ï

IX.
Appendix

APPENDIX A Project brief

DESIGN FOR our future

TUDelft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Ruijs

initials: LE   given name: Laura

student number:

street & no.:

zipcode & city:

country:

phone:

email:

Your master programme (only select the options that apply to you):

IDE master(s): IPD / DfI / SPD

2nd non-IDE master:

individual programme: - - (give date of approval)

honours programme: Honours Programme Master

specialisation / annotation: Medisign / Tech. in Sustainable Design / Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Richard Goossens   dept. / section: Physical Ergonomics

** mentor: Sylvia Pont   dept. / section: Perceptual Intelligence

2nd mentor: Jon Pluyter

organisation: Philips Experience Design

city: Eindhoven   country: The Netherlands

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

Procedural Checks - IDE Master Graduation

TU Delft

APPROVAL PROJECT BRIEF
To be filled in by the chair of the supervisory team.

Digitally signed by rgoossens Date: 2022.01.24 09:13:01 +01'00'

chair Richard Goossens date 24 - 01 - 2022 signature

CHECK STUDY PROGRESS
To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 30 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 30 EC

List of electives obtained before the third semester without approval of the BoE

★ YES all 1st year master courses passed

NO missing 1st year master courses are:

Kristin Veldman — Digitally signed by Kristin Veldman Date: 2022.01.25 10:53:15 +01'00'

name K. Veldman date 25 - 01 - 2022 signature

FORMAL APPROVAL GRADUATION PROJECT
To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ★ APPROVED NOT APPROVED

Procedure: ★ APPROVED NOT APPROVED

comments

name Monique von Morgen date 01 - 02 - 2022 signature

Personal Project Brief - IDE Master Graduation

TU Delft

Designing a better experience for Integrated Medical Image Guidance — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 20 - 01 - 2022 13 - 06 - 2022 end date

INTRODUCTION **
Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Currently, Pancreatic cancer is one of the most deadly types of cancer and has only a 5-year survival rate of generally 10%. Surgery (pancreatoduodenectomy) is the only form of curative treatment for patients diagnosed with pancreatic cancer. The assessment of the resectability of the tumour, based on Computed tomography scans, can be critical and demands expertise.

Philips, collaborating with Catharina Hospital Eindhoven and TU/e, has an oncology team (e/MTIC)working on health care innovations regarding Pancreatic cancer and Lung cancer enabled by AI and Medical Image Guiding.

This graduation project concentrates on improving healthcare professionals' user experience and interaction within an integrated imaging workstation. Entirely focused on visually communicating tumour detection and vascular segmentation for better diagnosis and surgical planning. The aim is to design a visual language (a design language system guideline) for the health care staff to improve the workflow and experience.

The core of this project is focused on the pancreas cancer use case. However, the design will be stress-tested with similar topics; the lung cancer use case and a few existing software products (specifically ISP and IGT applications with 3D anatomical visualization using Computer-Aided Detection tools) to show the scalability of relevance.

The stakeholders in this context are mainly the healthcare professionals (mostly: radiologists and surgeons, secondarily: pathologists, gastroenterologists and oncologists) and eventually also the patients.

This graduation project aims to visualise interactions within an integrated medical imaging workstation enabled by AI (Computed Tomography, 3D rendering and quantification panel). Moreover, ultimately, developing a design language system guideline (DLS) specifically for other/similar (healthcare) projects within the company. Conclusively, Philips will be able to improve its design solutions and innovations in the health care industry.

space available for images / figures on next page

Personal Project Brief - IDE Master Graduation

introduction (continued): space for images

image / figure 1: Integrated imaging workstation for pancreatic cancer

image / figure 2: 3D model in Looking glass display

Personal Project Brief - IDE Master Graduation

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Scope:
Considering the assessment of a tumour/vascular segmentation (pancreatic cancer) and nodule detection (lung cancer) in medical imaging is quite complicated and, consequently, impacts the chance of survival rate of the patients. Therefore, improvement in the workflow and experience of the health care professional can improve the patients' odds of survival. Accordingly, I want to focus on enhancing the experience of the health care professionals in Medical Image Guidance to improve tumour/nodule detection and vascular involvement for better diagnosis and enlarging the chance of survival for patients.

Implementing AI in healthcare solutions has a lot of potential to improve cancer care. However, in order to integrate AI, the workflow and user trust must be optimised through UX design to ensure functionality within clinical practice.

Solution space:
Fast, easy and trustworthy interactions across medical images and AI-generated 3D models will enhance the workflow, and user experience within an integrated medical imaging workstation will be the focus of this graduation project.

This leads to the following research question:

How can specific interactions and visualisations within an Integrated Medical Imaging workstation be improved in order to enhance the user experience of the health care professionals?

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

A design language system guideline will be developed to enhance the experience and workflow within an Integrated Imaging Workstation. Therefore, this project will explore ways to support the performance of health care professionals through UX and UI implementation.

Currently, this project has been running for 1,5 years now, and a user test has been done. At the start of my project, I will start with the insights from those user tests + my expert design review. Moreover, I will explore the strengths and weaknesses of the UX and UI- technologies to decide on possible ways to improve the experience of the health care professionals.

With my explorations, I will eventually visually design the communication towards the health care professionals in Philips' integrated imaging workstation. Moreover, work on the next iteration of the prototype. Ultimately, I aim to develop a design language system guideline that can be implemented in similar projects or diagnoses in the future.

During this project, I want to use the pancreatic cancer use case as a reference to design a DLS guideline (design language system) for medical (imaging) purposes. I will test this design guideline with similar topics; the lung cancer use case and a few existing software products (specifically ISP and IGT applications with 3D anatomical visualization using Computer-Aided Detection tools) to show the scalability of relevance.

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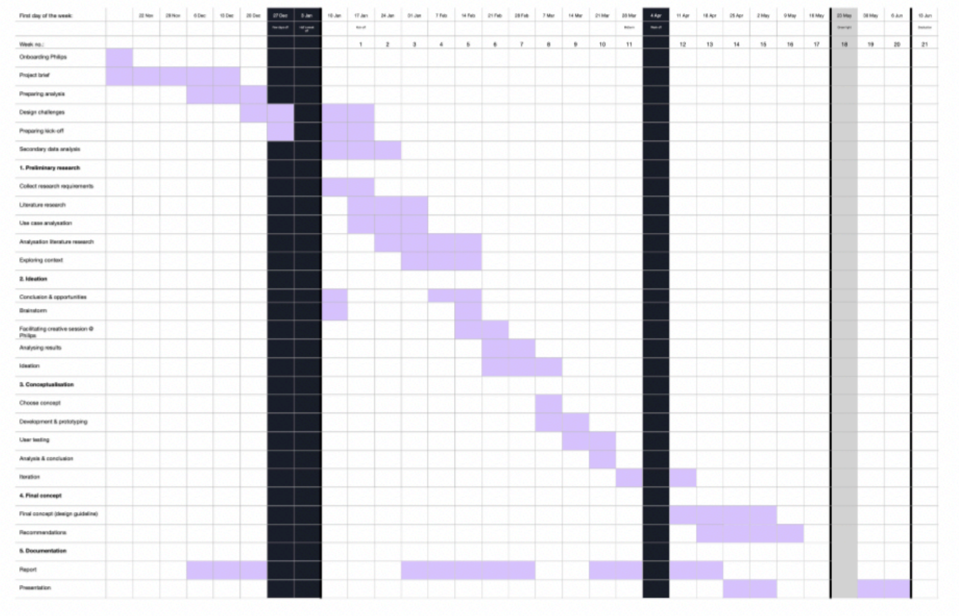
PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 20 - 1 - 2022 | 13 - 6 - 2022 end date



The planning above consists of 5 parts and four stages:

1 First, I want to start my graduation project by collecting insights from previous steps within the use case, viewing use case interviews, performing a secondary data analysis (and possibly attending a pancreatoduodenectomy). I tend to gain more insight into the context and collect the requirements for my literature research. In short, pre-scope field of research. Eventually, doing (visual and scientific) literature research, focussing on; similar applications, visualisation and interaction with AI segmentations/3Dmodels and quantifications.

2 Closing the first phase, I will be able to draw some conclusions and design opportunities. After framing and scoping these, I can start brainstorming some ideas.

3 Eventually, I will choose 3 or 4 concepts to develop + prototype. I also intend to test the prototypes with stakeholders in the pancreas use case and other UX designers to test the usability of the design language guideline. Eventually, evaluate the results, and implement iterations in the design.

4 Finally, I would have two deliverables with recommendations. One deliverable for the pancreas use case and another is the design language guideline (for visualisation of 3D models and quantifications) that can be implemented in similar projects.

5 The bottom part of my planning demonstrates the progress of the documentation of my graduation project: both the report and the presentation at the end.

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MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

During my bachelor (Industrial Design Engineering, TU Delft), I discovered that I am the kind of designer that likes to explore the implementation/finalization of a concept after the analysis phase. This means deciding on the visual aspects and all of the interactions and experiences within the concept. Therefore, the decision for the master DFI (Design for Interaction) was quickly conducted.

Nevertheless, I've always regretted not doing the Medisign specialization since being a doctor/surgeon; however, not pursuing it is another career path that has always intrigued me.
The chance provided by Philips to combine UX/UI, visual communication design and healthcare is a perfect opportunity to finalize my master's degree in this graduation project.

In order to develop myself during this graduation project, I came up with the following learning objectives and achievements.

1 Learn how to implement UI/UX solutions in practice. I've never experienced applying these techniques in a corporate environment. I have gained some experience with UI/UX design master courses and extracurricular activities, however never in a professional environment. I intend to achieve this experience by developing a UX/UI solution by designing a DLS guideline for Medical Imaging Guidance within a professional health care environment.

2 Personally, I also want to learn to work with non-designers. Moreover, learning how to communicate (my designs, for example) to other (non) designers. During my graduation project at Philips, it is very likely that I will learn how to do that since I'll be working in a professional environment. For me, this means working in a team with other people and other professions, and I think this also means that you can learn a lot from each other.

3 Learn more about the setup and structure of a big company and how innovative technologies are implemented in practice. Doing my graduation project at Philips will probably give insight into this. Achieving this I might be able to visualize witnessing the whole process of innovation to product realization from up close during my project at Philips.

4 Getting a better understanding of design for health care purposes. This is also something I don't have much experience with, but I am eager to learn more about this and execute my learnings during this project. First, I would have to get more familiar with health care in general; this will happen during my (literature) research at the beginning of this project. After this, I will start ideating, iterating and user testing several concepts, which will help me to understand the implementation of design in health care solutions (learning by doing).

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.