Lung nodule puzzle generation:

Crowdsourcing nodule detection tasks via gamification

Design for Creatives squad B2.2

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I. Abstract

In collaboration with the Medical Image Analysis Group of Eindhoven, this project looked to make a successful interface for the annotation of medical images. Using the tool crowdsourcing to annotate images of lungs and therefore, provide training data for a machine learning algorithm. The application that was made is a game called NoDe which translates the actions of the user to data for the algorithm. NoDe provides not only a fun game, but is also educational, simplistic and guiding. Therefore, crowdsourcers with or without prior medical expertise will be able to play this game.

II. Introduction

In today's society, we benefit greatly from the medical innovations that were made. Nevertheless, there are still improvements that need to be made. Such as, making a fast crucial diagnosis in treating a patient. The prognosis of advanced lung cancer is very low, this means that the mean of the patient's survival time is less than 12 months(Hua et al, 2015). Thus, early detection is necessary to improve the chance of survival rate.

However, the speed of the diagnosis should not take away the quality and accuracy. These early diagnoses can be made possible with the help of machine learning algorithms. Ilyasova et al. (2018) discusses about how the use of big data processing techniques enhances the accuracy of the diagnosis that is made. In analyzing the medical images through these techniques e.g. machine learning algorithm, it is explained that the bigger the data set the more accurate the outcome(Ilyasova et al., 2018).

Without such an algorithm to help the medical experts in the diagnosis, the diagnosis time can take up to a couple of weeks till more than a month(Birring, Peake, 2005; Verma et al., 2015). As explained in the first paragraph the sooner a patient is diagnosed the more chance the patient has to survive. But to train such an algorithm there is a lot of data needed. To gather this data for lung nodule diagnosis, large sets of annotated lung images are required. The problem is that it is very time-consuming to annotate each image for a medical expert and the more people annotate an image the higher the accuracy is for the algorithm.

Another way to annotate the images is by using crowdsourcing platforms. By using this there will be no extra time taken away from the medical experts. Using the masses to annotate the images will create a wider variety of people annotating each image. Meaning more annotations per image. The downside of using such a platform is that one needs to pay each crowdsourcer. Therefore, it would be a costly resource.

There are already some datasets created of annotated lung images. For example by McNitt-Gray et al. (2007). During this research they used 4 medical experts(radiologists) per image to annotate. However, this dataset is not very large. At the end of the paper they annotated 100 images and are aiming to continue to a 1000. With the help of crowdsourcing with the masses(common people), more images can be annotated.

By combining crowdsourcing with gamification we can use the masses of people to annotate the medical imaging. And this being while these people are playing a game. It is not the first time the strength of the masses were used to help the medical innovations by playing a game. For example, Eyewire (z.d.) uses gamification to map the neuron network of the human brain. And Foldit(Peckham, 2011) uses gamification to unfold protein chains, such as the aids virus. Our application differs from these medical games in the way that EyeWire and Foldit let their users "solve" the puzzles directly.

With our current application we don't let users(gamers) diagnose a patient, but, collect data to train an algorithm. We are using known methods but direct them in a new way. We do this by combining the knowledge of crowdsourcing, machine learning and gamification and redirect that knowledge into helping doctors detect lung nodules.

III. Methods

Collecting and analysing

As the problem statement from the client, was already quite clear. We started brainstorming about our stakeholders and features we would need for a concept.

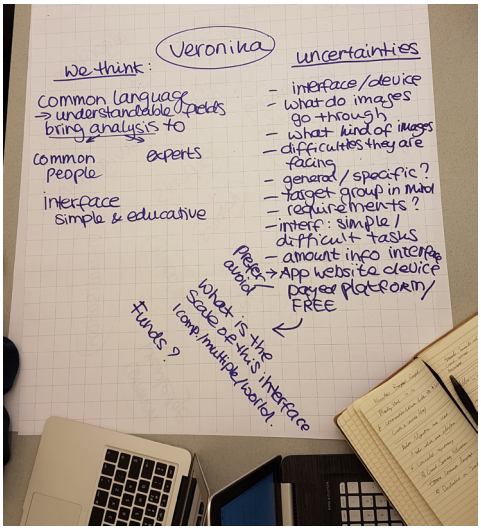

Fig 1 'Brainstorm

A user flow graphic was made, showing a conceptualised patient and their path to being diagnosed. We looked at the different stages of this process and tried to see where we can better this process. As discussed in the Introduction, we found that the process between making the CT scans and actual treatment can take far too long. Earlier diagnosis means a lower chance of death by cancer (D Holmes, Y Chen, & Feskanich, 2005), so having a system like this implemented that can speed up this diagnosis process would be greatly beneficial.

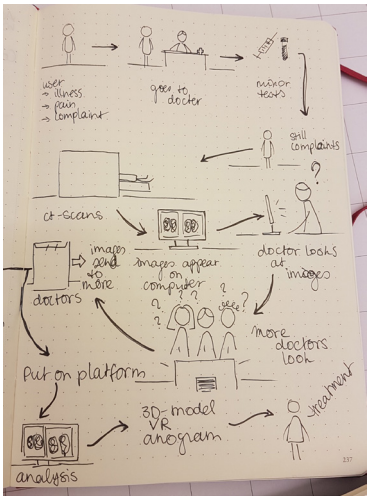

Fig 2 'Storyboard'

To start exploring our case, we wanted to gain more insight in our stakeholders and users. A stakeholder map was made, visualising the 3 main stakeholder groups: IT support, Medical image sources, Medical research. Our product would be placed where all of these stakeholder groups merge. The system can be used by every group, but for a different goal. Medical staff would be able to use the system to further their research on certain topics or get annotated patient data. IT support is able to use the annotated data to train their algorithms. Patients provide the image data and benefit from the insights that the medical staff gets from their data. All of these stakeholders overlap as the function of crowdworkers/users for the system.

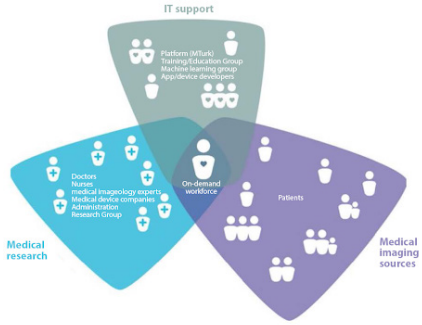

Fig 3 'Stakeholder map 1'

To appeal to the crowd, we thought about adding a educational part to our system, where users learn about these advanced topics while annotating data. This keeps the users motivated as it gives them a sense of immersion inside of our system(Yee, 2006). This would help us keep a community of users annotating data.

Conceptualisation

Because we work with crowdsourcing, we need to keep the users motivated to keep on doing these tasks. We wanted a way that would be sustainable for long-term use and for it to be adaptive, for when our system would be used for something other than lung nodule detection. Paid crowd worker platforms such as Amazon Mechanical Turk (n.d.) and Figure Eight (n.d.) were researched, but were discarded as this causes the whole system to need a sponsor, which isn't sustainable at it's core level. This also limits the amount of tasks that can be completed because a budget is required for such a platform. (e.g $100 (budget) / $0.05 (Payment) = 2000 maximum tasks) The limit causes a choke point in the crowdsourcing method.

After the lecture from GameBus (n.d.), it got us thinking about Gamification, and how this would benefit us. At this point we had some problems in our concept, especially with one question; "Why would people annotate the data?". While MTurk or Figure Eight would give the users the motivation, it gave us negative points we didn't want. However, Gamification gave us more answers. User motivation must come intrinsically from the users themselves if we want the users to continue without pushing or keeping a check on the users. We quickly thought of a leveling system to keep the users interested in annotating the data. For doing the annotation tasks, the user would get experience points. After gaining enough experience the user would level up and would be awarded another title.

Annotating lung nodules can be done with several levels of data. The two levels we focused on were detection and classification. The former giving locational data on any present nodule and the latter giving data on the malignancy of the nodule. This level of danger can be identified by the physical properties of the nodule (Hussein et al, 2017). With feedback from our client, we concluded that pure nodule classification is a hard task, and detection should be the focus. However, users could give a physical description of these nodules and be sorted on expected severity.

An algorithm would sort user input and the images, so that other game data could be generated by the answers of previous games. For example, a nodule detection game would give nodule location data that could be used to locate nodules and use them in a classification game. This concept was worked on and the beginning of a neural network was programmed. However, we focused more on our main application instead of implementing the algorithm.

Virtual or physical application

To be able to decide what direction we would take 3 concepts were made. The first concept was to create an interface, usable on systems such as the Eindhoven city beacons. People walking by can use the interface and learn about nodule detection as well as annotate data. But this posed a few problems. The motivation by leveling-up isn't easy to do in such a situation. Also, false annotations is not easy to sort out this way, as random people with bad intent can also use this system. Furthermore, cancer is often a subject provoking negative thoughts. Which raises the question of: is that something one wants to be confronted with while doing groceries shopping?

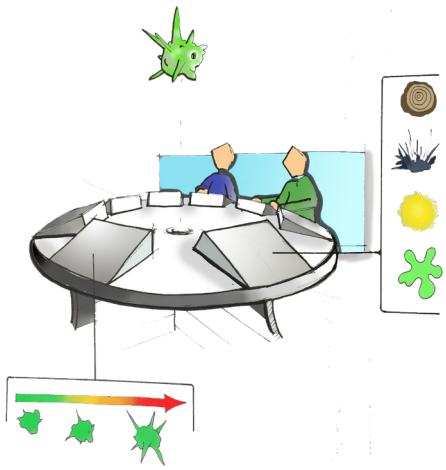

Fig 4 'Museumconcept'

The second concept was an interactive, educational installation. This was to be implemented in a museum such as CORPUS (n.d.), which is a museum about the human body. As visible on the sketch, there are a couple of screens that the children in the museum can use. This table would have a game interface where children could annotate nodules in a fun way. However, this concept was also a not as good, because our only users would then be mostly children and only limited to people visiting a museum. This limits the amount of data that can acquired. The tasks may also be too hard for children, so we decided to focus on the last concept.

The last concept was a mobile application. Here, users will be able to sign in to their own account and do annotation puzzles. We decided, based on a questionnaire through the Design for Creatives squad, that is would be best to continue with this concept

NoDe Application

The Nodule Detection application is our prototype of the concept mentioned above and we developed this as our demo-day prototype. We started with thinking about what kind of game we want to implement the data annotation in. We brainstormed about different types of games in which we could receive and send data in, without making it too hard for the user.

These games are: Spotting the difference, Shoot the lung and find the nodule. In the end we went with the find the nodule type, because we found that we can control the data flow in this type of game very well.

Fig 5 'Screenshot Game concept'

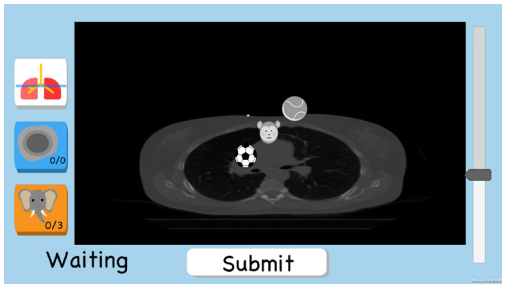

Fig 6 'Screenshot Game concept'

The first iteration of the game assets looked like this. The feel of the game was supposed to uplift any negative feelings the user could get, because lung cancer research is generally not a happy theme. Features of the game were listed and prototyping began for the midterm demo day.

Platform Concepting

To include all of our ideas, we planned to make 2 other applications. One was the app platform, where users could log in, see their statistics in games, team up with friends and choose a game to play. Several games would be included in this app, but the only example game would then be NoDe. The other application was a website, designed for the developers. Here, the developers could upload new CT images and download statistics. All of these systems would thus be connected with each other and adding new games or other datasets would be easier to do. Appendix IV.A.1 and IV.B.1 shows the ideas we had for these concepts.

However, these 2 applications were later dropped, as we wouldn't have enough time to implement feedback or make changes in the NoDe app. Therefore, we wanted to implement our system with the framework of a masterstudent Carlos Santos, which was at its core what we were looking for. However, no contact was formed between us.

Fleshing out the concept

Based on feedback from the midterm demo-day we changed the whole theme of NoDe. From a more childish version to a more researcher theme. After feedback from the client and our user tests, we changed a lot of controls little things of the game. The whole UI was reworked twice before the final version, which was shown on the demoday, was implemented.

Fig 7 'Set-up DemoDay'

IV. Results

A user test had been done for the last iteration of this application (see Appendix V). Where 7 Participants tested out this application. These participants were divided over two groups. Group 1 were given the task lists, and performed these tasks with an explanation of the concept. There were 5 participants in group 1. Group 2 was asked to play the game without any explanation. There were 2 participants in group 2.

The results of this user-test were that only 2 out of 7 people found a nodule, of which 1 participant found it by accident. And the ones who found it all came from group 2. But from the feedback it became clear that no one really knew what a nodule was. However, almost everyone found the artifacts hidden in the scan. From this we could conclude that the par-

ticipants did understand the interface, but lacked information about the characteristics of a nodule.

During the user test, there are several findings listed as follows that were very important for our final design.

Users prefer an interactive tutorial

For an application like a game, users already expected it should be fun, therefore a long and wordy introduction will run out of users patience. Based on our observation, allowing users to perform subtasks during the introduction can keep their interest to continue our game. Quote: ***"I feel like to skip tutorials directly, they look too long and a bit boring."*** (Male, 19 years old student from industrial design faculty.)

Consistency of operation

The application for user test used pinch & spread gesture to go deeper inside the lung chambers. However, users expect these gestures for the function of zoom in and zoom out. So later the Go-through-the-lung function was using scrolling with two fingers to operate. And the function of zoom in and out was added by pinch & spread gesture. Quote: ***"I thought spreading the image would make it larger instead of go deeper."***(Female, 20 years old student from industrial design faculty.)

The artifact-discovery rate cannot represent the accuracy of the nodule-discovery rate. The nodules location is unknown to the application, therefore our team cannot rate if the players find the right nodules. To solve this problem, our team designed the artifacts spreading around the lung chamber. The location of these artifacts already known by us. We assume to use the artifact-discovery rate to represent the accuracy of the nodule-discovery rate. However, during the user test, all the users could find the the artifacts but few of them was sure that they find the nodules. This was because the difficulty of finding these 2 objects were not the same. The artifacts were very obvious while the nodules were harder to distinguish. quote: ***"Yeah I saw the artifacts! But i could not really decide what is a nodule."*** (Male, 21 years old student from industrial design faculty.)

Final Design

The name of our design is called ' NoDe '. It is a game that can guide crowd sources to find nodules as the database for algorithm developers. Gamification was implemented because research has shown 'how implementations can increase crowdsources' motivation and participation in crowdsourcing(Morschheuser, Hamari, Koivisto, 2016).

Stakeholders

There are mainly 3 characters: Users, IT support group and Medical experts. These three characters exist of many different people with different backgrounds. For example, they can be medical-related workers/students, specialists from other domains. The users are the crowd sourcers on the internet of which most without medical knowledge. The crowd sourcers will locate the nodules in the application. The input of the crowd sourcers via the application will provide the computer with data it can learn from.

IT support group will analyze all the results and develop the algorithm which eventually enables a computer being able to detect nodules by itself. Medical experts will provide the CT scan images to this application and get helped by the results for their own medical research

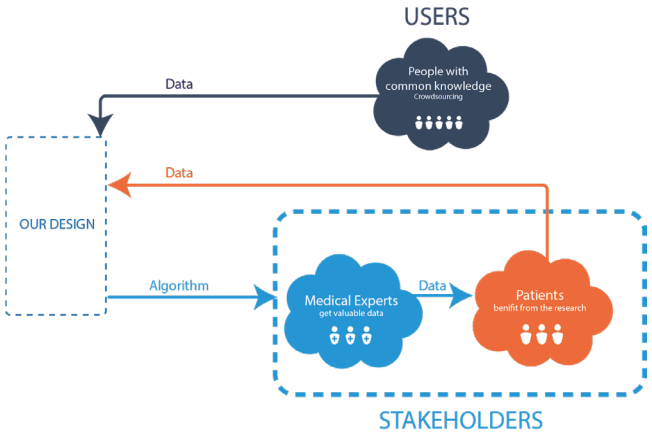

Fig 8 'Stakeholdermap 3'

Function

With NoDe we have used the game element 'hide and seek'. Which stimulates the user to search through the lungs chamber to find nodules and hidden artefacts. In every lung chamber, one or more artefacts is/are

V. Discussion

hidden and it is up to the users to find these artifacts to improve their own accuracy score. Not only the artefacts, but also the found nodules contribute to this.

Furthermore,our application contains an interactive introduction. Because from our user tests it was shown that people lack visualization and knowledge of nodules. As well as, that the users perform better after having shown an example or tutorial.

Fig 9 'Screenshot Game Final Design'

Fig 10 'Screenshot Game Final Design'

Appearance and Interfacev

The logo of the application was a human-shaped nodule, which has the metaphor that the lung nodules depend on the crowd sourcers to detect. A series of blue was chosen as the main color of this application because blue can build an atmosphere of health and laboratory research. A female doctor is the game character who will introduce the tasks for the users. All the lung CT scan images were collected through the website Cancer Imaging Archive(https://bit.ly/2LXTbfS).

Two main problems were identified. Firstly, having a long diagnosing time, whilst early detection is crucial. Secondly, the amount of data required for machine learning is enormous and will be time consuming to collect.

Aiming for a shorter diagnosing time is a problem not directly addressed, because a shortened detection time was not something we validated during the project. Instead we looked at what was necessary to achieve this goal, such as a machine learning algorithm with a lot a training data. Therefore, the second problem is what we focused on '***How to get this large training data set for machine learning.***'

However, our project shed light on the possibilities for the annotation of medical images and explored creative possibilities, such as the gamification of nodule detection.

on can add to their knowledge as well. We find it important that this application will be educational for all parties involved. However, as can be read in the results, this is currently not the case for most users.

User tests

The target group we had in mind has not been sufficiently researched and tested because the diversity and wide range of skill lacked in the conducted user tests. The majority of user testers were students at our own university, Technical University of Eindhoven, and had the age between 18 and 22. Therefore, our goal, to provide a game that can be played by anyone without any prior medical knowledge, has not been sufficiently substantiated.

In order to probe the usability of the application for people without prior medical knowledge, we should have further iterations to develop the introduction of the application. The absence of the visualisation of nodules in daily life should have had more focus during designing the application and have even more focus when improving it in the future. Without medical knowledge one can play this game but without knowledge of nodules one will not keep playing this game.

Perhaps a 'training' for the user is needed before being able to produce trustworthy data. This could be visu-

alized by choosing the nodule out of two similar pictures. This way the user can become familiar with the subject and contribute as a crowdsourcer. When considering the abilities of the user we are discussing not only how users can add to the research but how the application can add to their knowledge as well. We find it important that this application will be educational for all parties involved. However, as can be read in the results, this is currently not the case for most users.

Domain changes

The medical image annotation domain changes when outsourcing data annotation without costs through gamification. When progressing this project further, this game can be a starting point to shorting diagnosing time within the medical imaging field. Better research should be done to identify potential issues. For example, regarding privacy regulations and ethical standards.

For doing the annotation tasks, the user would get experience points. After gaining enough experience the user would level up and would be awarded another title.

Future

For now, the application focuses on the detection of nodules. However, in the future we would like to move towards nodule classification. That a computer can locate a nodule and classify it as well.

VI. Conclusion

To try to shorten diagnosis time and therefore increase the survival percentage of cancer patients, we developed NoDe. A gamified research app, where users can help by doing tasks on making puzzles out of lung CT data. In making this process a game, we are able to crowdsource these tasks. For this a platform can be made that may be used to gather a lot of this data. This dataset could then be used as algorithm training data. To be able to automate this process of detecting these lung nodules in the long term.

The adaptiveness of the system was conceptualised, but not fully worked out in the end. As the focus on the lung nodule example gave us more work material, then we first anticipated. The 3-part platform, that is explained in methods, is a good example of how adaptiveness would be integrated.

User testing was done, but not enough. This should have been done far earlier. But do to the troubles in the beginning of the process, we had not enough time to make testable MVPs. However, a lot of user test results from the midterm demo-day and from our client did help us was utmost useful. And therefore, we could still make a lot of adaptations to our first NoDe game, and its interface.

This platform has a potential in being an adaptive, playful and helpful data gatherer, where further research with this data can be beneficial.

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VIII. Reflections

Anne

When I chose the direction of working in the IM-AG/e team I did not know what to expect. I wanted to challenge myself in choosing I a project I had little knowledge on. The understanding of collecting data and training an algorithm was new and sometimes confusing to me. Luckily, my teammates understood this problem. They either did not understand it either or were willing to give an explanation. Therefore, working with such a diverse group was utmost useful. There was a free speaking atmosphere which meant, the communication went quite well. I feel that we could all contribute to the project to this project in a different manner. Since for me the subject of algorithms and programming was fairly new, my contribution in creating this was minor. Nevertheless, I learned a great deal on the subject of crowdsourcing and how a machine learning algorithm works. From the different workshops of Figure Eight, GameBus and on machine learning, combined with my own research, I noticed that the once vague subject became more clear to me. Because, I could not contribute too much on the subject of programming the final product, I focused more on the different subjects. Creativity, planning, researching, ideation and tried to help where help was needed. In creativity and Ideation I added in value by being a present voice in de discussions of concept making. Furthermore, I created the one of final posters, helped in creating the visuals of the game and translating the feedback to what needed to be improved upon. In planning, even though I know it can be one of my weaknesses, was present. By booking rooms, tried to keep tract and with the help of my teammate Noa made multiple to do list, so we as a group had a clearer idea on what our next step would be. When it comes to the research that was done in the project, I took the lead. I found it important for myself to improve on this subject. Since, this is a useful skill to have. I did noticed about myself that this improved after the workshop that was given about this subject. I became more aware in what I needed and how I should go about with the information. Finally, in creating the report my contribution consisted of making the abstract, introduction, layout, putting all the references in the correct 6th generation of APA and correcting on other parts of the report.
From this I could say that the subject of the of the assignment was difficult for me sometimes. However, that was why I chose it to take on a challenge. And even though, I learn a lot I wish I could have meant more in the creation of the app. This is something that I can approve upon in the future. Also I learned the importance of starting the creation concept earlier in the project. Because we had some confusion at the beginning we started later than anticipated.

Guangyu

Introduction

I chose squad Creative for Design for Project 2. My initial goal was to develop more in the technology competency. I'm in a group of 4 people and luckily the other 3 teammates are also willing to put efforts in this project.

Behavior

For myself, I would put the highest quality I can do for every task. And I am critical to not only my own work but also other people's work. However, there were several times I delayed the pre-due day that our team set. In the future, I will plan better to finish everything on time. For the team, other members are very open to share opinions so the atmosphere in the team is free and fair. We had a regular group meeting every week so we can work together and got the conclusion together. Besides, all the teammates would love to share their knowledge and teach others. We learnt a lot from each other. Compared with the first year, the working pattern of the team improved. Every week, we allocated the workload very specific. I think this helped us to work more efficiently.

However, there are also 2 problems in our teamwork: Although it is good to have many iterations during a design process, changing concept direction completely each time might not be the way to develop the project. Actually, It was not any members' fault because

every iteration was approved by all of us, but after working on it for a week it turned out to be not good or unnecessary and the workload seemed wasted. I think one thing we can do to avoid this is to look for tutors' advice in the early stage of each iteration. But on the other hand, this problem can also be a good experience for us. By failing a lot now, we can find the right direction easier in the future. Another problem is we were always chasing the deadline. Everyone was so freaked out and irritable before the due day. Although we finally survived and done it pretty well, I hope in the future we can play safe for the project.

Identity

I'm good at Adobe software like Id, Ps, Ai, Pr, so in our group I mainly responsible for the visualization parts for every iteration. I made the interface of the game and designed the game characters. Besides that, I also did much research to help with the design concept. It's a bit pity that I didn't develop as much as I expect in the technology aspect. I learnt some new terms and concepts like crowdsourcing but I didn't join the programming part. Although the teammate who did the programming would love to teach, the program can only present on the PC, instead of the laptop. So we cannot really help or involved in it. For the team role, I would like to develop my leadership ability then I'll become more flexible to play any role in a team.

Joris

I chose for the Design for Creatives squad because of my interest in AI and machine learning. I wanted to better myself in these concepts and this squad gave me the best impression. As my competence in technology and realisation, and math, data and computing were already quite developed, I also wanted to get more experience in a business perspective. Working with real clients gave me this opportunity to hone my skills in business and entrepreneurship. My choice was stuck between the safety network and IMAG/e project. But ultimately, I chose for IMAG/e, as data research interested me and this project allowed me to learn about this. It was a shame however, that our client had other ideas about a project, which could've very much worked as a research project, but not as a design project. This left us with the first few weeks of concepting and not really getting a grip on a direction. But I think the results were very well still, and would've liked to continue developing a platform based on this concept.

Last year, I had a lot of problems with motivation and maintaining discipline, but this year I had a far better feeling when starting the project. Having been able to choose my own project from the beginning and not to be 'stuck' with one, really did boost my motivation for the project. I noticed that I was able to deliver more work, as I try to deliver high quality work.

In this project I mostly put my time in programming the applications and doing research on data, algorithms and such. As my colleagues were not as experienced in data or programming, they mostly focused on other stuff, where I was able to learn from. For example, making a realistic planning for a project. I learned a lot about communication with each other, but this time in a more work manner. Last years, I had experienced communication in a meeting manner and learnt from this, but now, problems occured with the delivery of files. I noticed that when someone is inexperienced in a certain field, also the delivery of files is not as fluid. For instance, game assets were all delivered in one big concept file, with user interface assets spread around. From this experience, I know how to handle the next situation like this better.

I was able to work on my vision during this project, as part of the problem was that most similar systems only work for one specific part of data. For instance, the last project in team Melago, focused on skin diseases. This need for adaptivity really matched up with a big part of my vision and being able to work with my vision in mind allowed me to develop it.

In the end I wasn't really able to better my skills in business and entrepreneurship as it wasn't really a company we were working with and our client left the development to us. In later projects I really want to be more active in including the industry and getting feedback from them. In terms of ma-

chine learning, I was able to improve my skills a bit. During the project, I gained more experience in machine learning theories and practical experience in programming a neural network. It is a shame that this feature wasn't implemented in the final design, but I would like to use these skills in my own private projects, business projects and further university work.

Noa

My responsibilities (listed in the references)

During this project I was responsible for the contact between us and our client, Veronika [15]. I found it important that Veronika would always be informed about our process, especially before meeting with her and that her feedback would be written down[8] and implemented in the project. Furthermore, I was responsible, along with Guangyu, for the visuals during the project. For me drawing on paper is easiest and especially in the beginning I made sketches[4], storyboards[6] and paper prototypes[7] on paper. However, I had set a goal to create more digitally and this happened to be my responsibility towards the end of the project. Posters[13], Logo's[11] and illustrations[5] such as our 'data process'[12]. The first three progress reports were my addition to the team as well [1][2][3] Behind the scenes I was taking on a more leading role and mostly bringing structure in the group by setting goals for the project and plan ahead.

Development

This project I developed myself more as a leading figure within a project and learned more about project management. How to keep meetings organized and structured, dividing tasks equally and making sure everyone was heard during meetings. On the one hand I am glad I got to see this side of me developed, on the other hand, it meant that sometimes you are busier with making sure everybody contributes that you forget your own input. This I realized half way through the project and it was then I decided to take up more tasks. Resulting in a growth in Creativity and Aesthetics and Math Data and Computing. When making a poster I learned that there is such a thing as too much text and even when I thought I had truly decreased word count, the feedback I got was still 'too much text'. This I hope to learn by asking a week beforehand if someone can review my work and discuss room for improvement.

My goal was and still is to develop in technology and realization. Unfortunately and luckily, my team member Joris is very good at programming. This was an asset to the team, since he is very skilled and knows his way around programming. Sadly, my goal was to improve my technology and realization skills. However, we were making an application, and no interactive product, and we had already someone qualified for this 'one mans' job'. Therefore, I did not have the change to improve this area unfortunately. Nevertheless, I worked on the UI and UE of the application and the other competence areas.

References

(chronological order of Appendix)

[1] Process Report 1	Appendix I.a
[2] Process Report 2	Appendix I.a
[3] Process Report 3	Appendix I.a
[4] Sketches Museum	Appendix II.b
[5] Some of the Icons	Appendix III.b
[6] Storyboards	Appendix III.c
[7] Paper Prototype	Appendix III.c
[8] Keeping a notebook	Appendix III.d
[9] Wireframe	Appendix IV.a
[10] Making User tests	Appendix V.a
[11] Logo	Appendix VI.b
[12] Data Process	Appendix VI.b
[13] Poster	Appendix VII.a
[14] Pitch	Appendix VII.b
[15] Log Client	Appendix VII.a,b,c

Appendix

I. Process

A. Process report 1

Link to PDF file:
https://drive.google.com/open?id=1aZjwYm_cqI4fdu8ASNJJfyhhrrunFxEs

B. Process report 2

Link to PDF file:
https://drive.google.com/open?id=1A5LE3c6FehWVLIHrxL-pwWeyegdGmpi6

C. Process report 3

Link to PDF file:
https://drive.google.com/open?id=1m2EiMSmG--5ScQMw5fo3TGnT9Ab2TnbJ

D. Process report 4

Link to PDF file :
https://drive.google.com/open?id=1F_livVAEy-ucDMWrmKZfUg2-8eoBrTJ8

E. Stakeholder Map

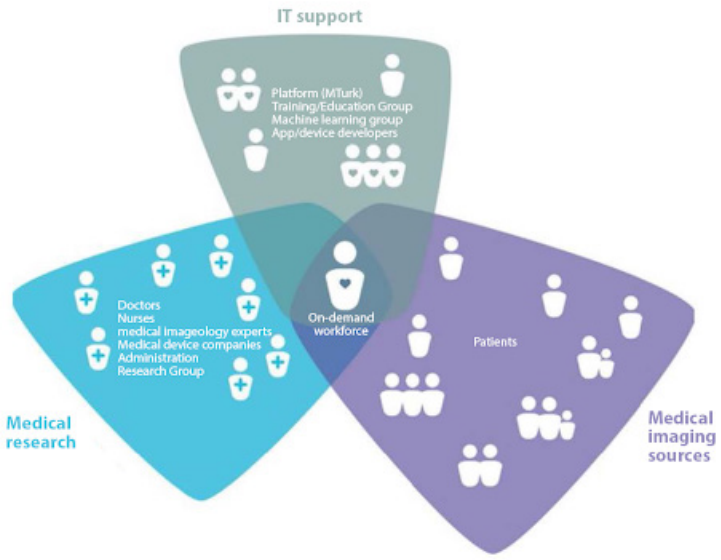


Fig I.A.1 'Stakeholder map 1'

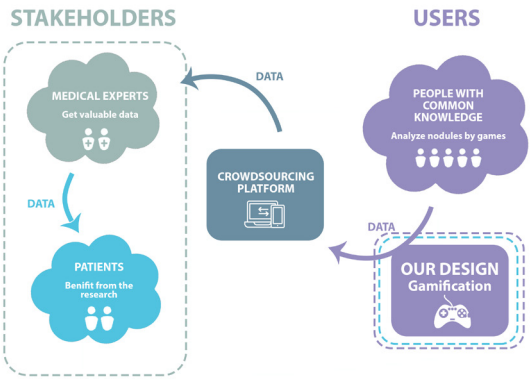


Fig I.A.2 'Stakeholder map 2'

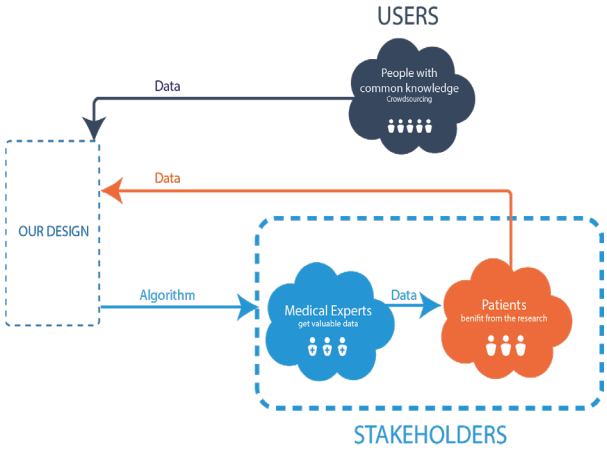
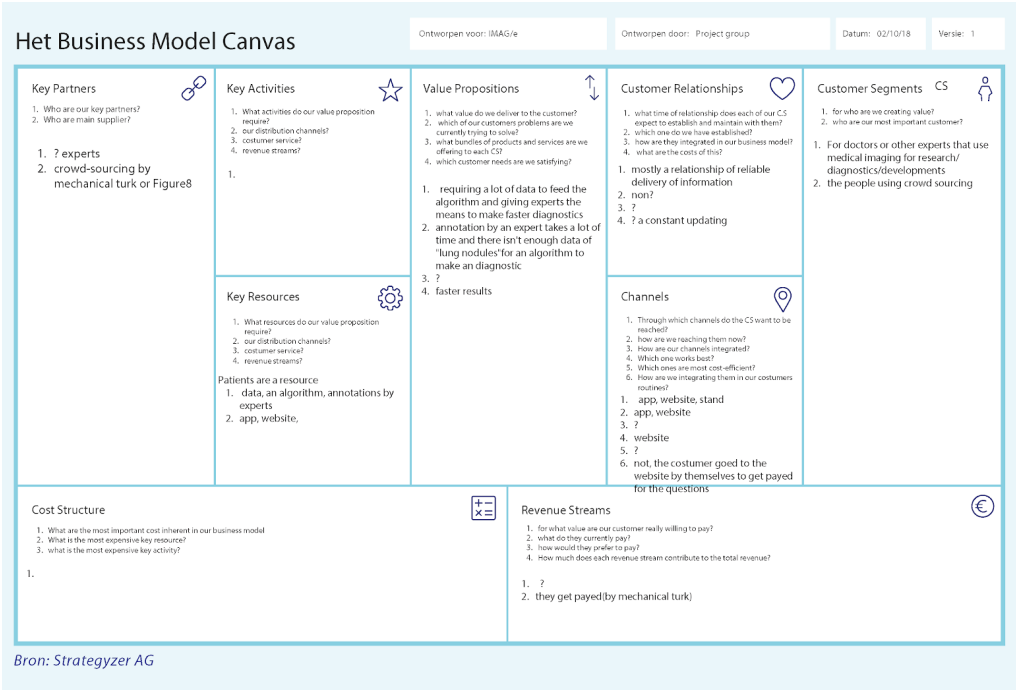


Fig I.A.3 'Stakeholder map 3'



Bron: Strategyzer AG

Fig I.A.4 "Business Model"

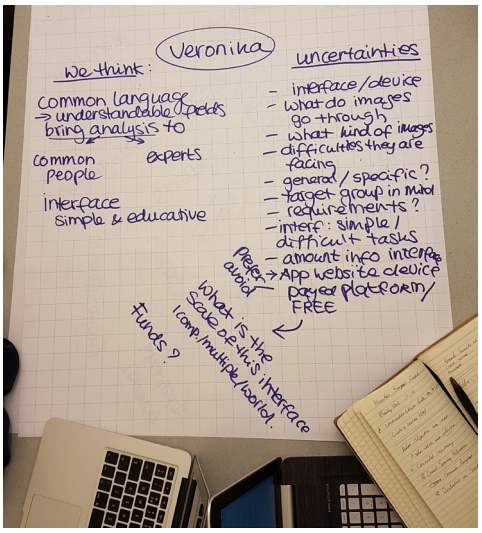


Fig I.A.5 "Brainstorm"

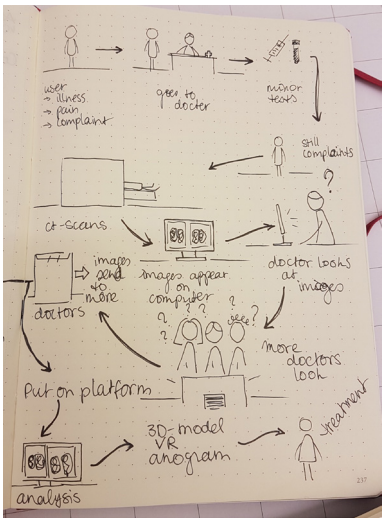


Fig I.A.6 "Storyboard"

II. Concept Presentation

A. Code

```
import neuralnetwork as nn
import numpy as np
import matplotlib.pyplot as plt

with np.load('mnist.npz') as data:
    training_images = data['training_images']
    training_labels = data['training_labels']

layer_sizes = (784, 5, 10)

net = nn.NeuralNetwork(layer_sizes)
acc = net.accuracy(training_images, training_labels)
```

Fig II.A.1 'Code snippets '

```
import numpy as np
import matplotlib as mp

class NeuralNetwork:

    def __init__(self, layer_sizes):
        weight_shapes = [(a,b) for a,b in zip(layer_sizes[1:], layer_sizes[:-1])]
        self.weights = [np.random.standard_normal(s)/s[1]**.5 for s in weight_shapes]
        self.biases = [np.zeros((s,1)) for s in layer_sizes[1:]]

    def predict(self, a):
        for w,b in zip(self.weights, self.biases):
            a = self.activation(np.matmul(w, a) + b)
        return a

    def accuracy(self, images, labels):
        predictions = self.predict(images)
        num_correct = [np.argmax(a) == np.argmax(b) for (a,b) in zip(predictions, labels)]
        print('{0}/{1} accuracy')

    @staticmethod
    def activation(x):
        return 1/(1+np.exp(-x))
```

Fig II.A.2 'Code snippets '

B. Visuals

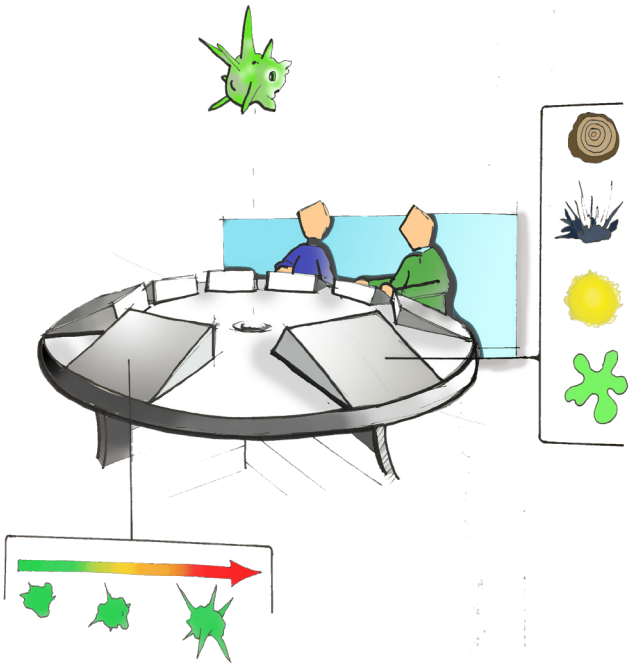


Fig II.B.1 'Museumconcept nodule classification installation '

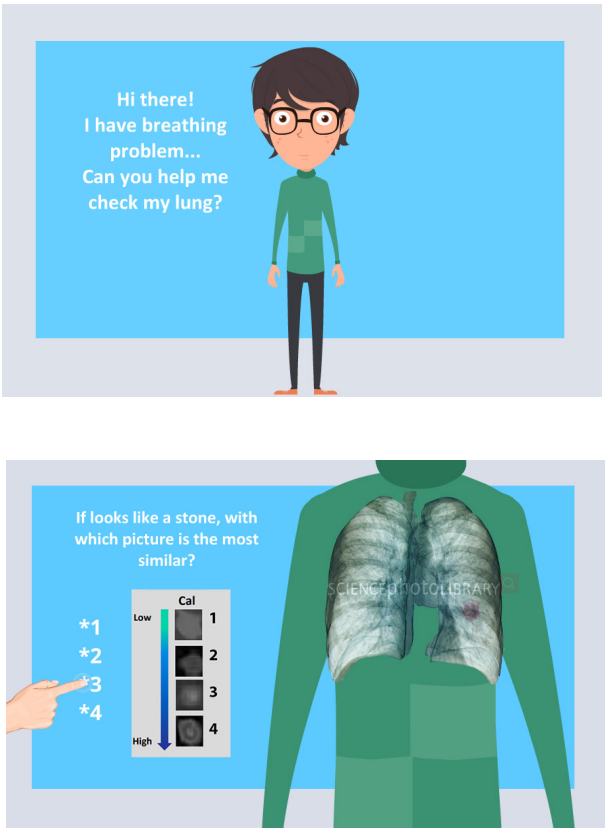


Fig II.B.2 'Interface concept nodule classification '

III. Midterm DemoDay

A. Code

```
84      [System.Serializable]
85      public class Game {
86
87          public string name;
88          public int index;
89          public Texture[] images;
90          public Nodule[] nodules;
91          public Artifact[] artifacts;
92
93          int nodulesFound;
94          int artifactsFound;
95
96          GameObject[] artifactsGameObjects;
97
98          public Game (int index, Texture[] images, Nodule[] noduleInfo, Artifact[] artifactInfo) {
99              this.name = index.ToString();
100             this.index = index;
101             this.images = images;
102             this.nodules = noduleInfo;
103             this.artifacts = artifactInfo;
104
105             SpawnArtifacts();
106         }
107
108         public void SpawnArtifacts () {
109             Debug.Log(artifacts.Length);
110             artifactsGameObjects = new GameObject[artifacts.Length];
111
112             for (int i = 0; i < artifacts.Length; i++) {
113                 int index;
114                 switch (artifacts[i].type) {
115                     case Artifact.ArtifactType.Elephant:
116                         index = 0;
117                         break;
118                     case Artifact.ArtifactType.Monkey:
119                         index = 1;
120                         break;
121                     case Artifact.ArtifactType.Football:
122                         index = 2;
123                         break;
124                     case Artifact.ArtifactType.Basketball:
125                         index = 3;
```

Fig III.A.1 'Code snippets Midterm'

B. Visuals

Fig III.B.1 'Screenshots Midterm Application'

Fig III.B.2 'Screenshots Midterm Application'

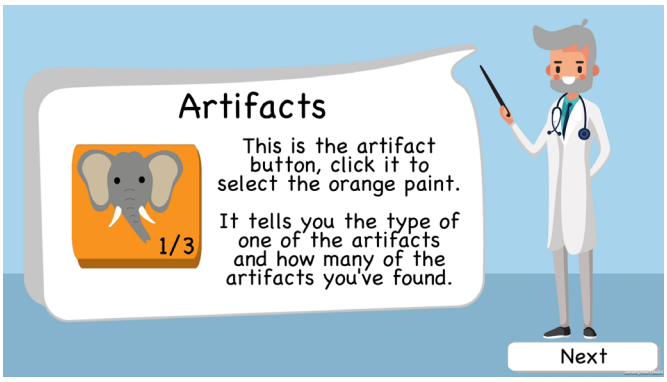


Fig III.B.3 'Screenshots Midterm Application'

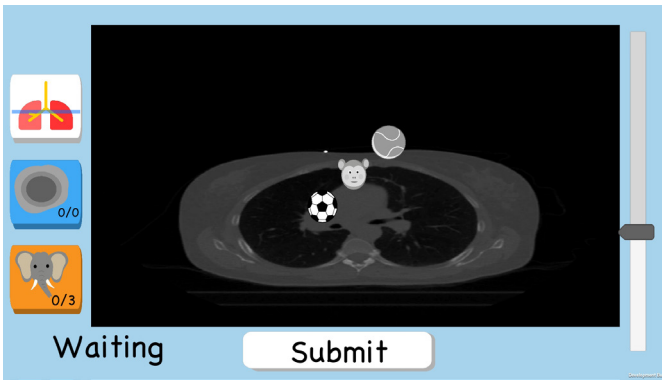


Fig III.B.4 'Screenshots Midterm Application'

Fig III.B.5 'Screenshots Midterm Application'

C. Storyboard

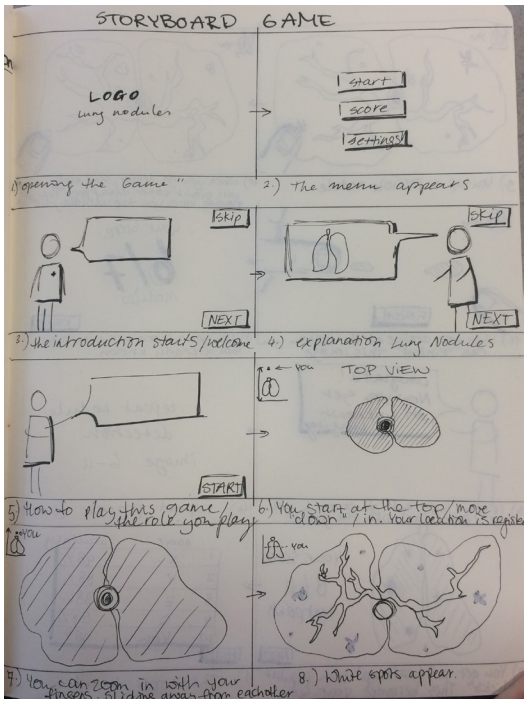


Fig III.C.1 'Storyboard game'

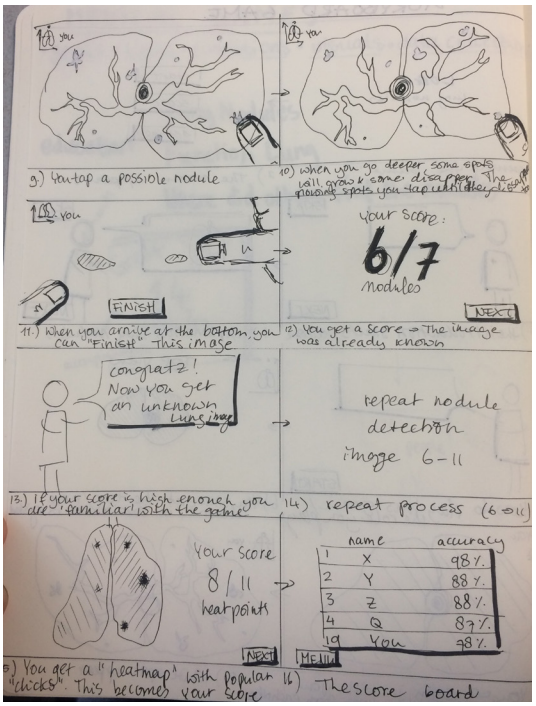


Fig III.C.2 'Storyboard game'

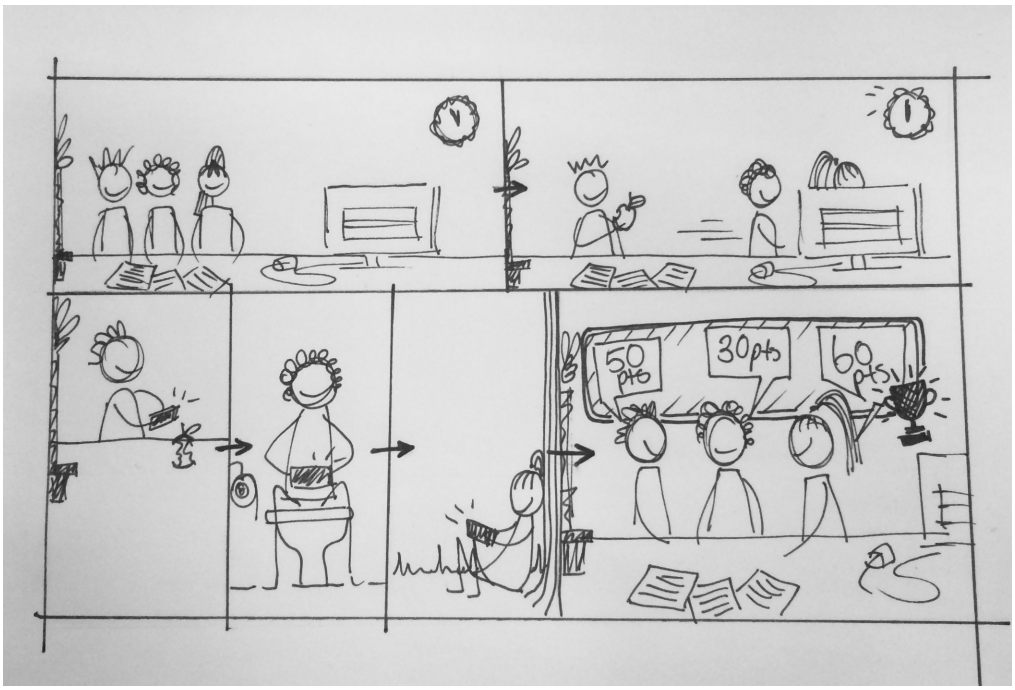


Fig III.C.3 'Storyboard playing the game'

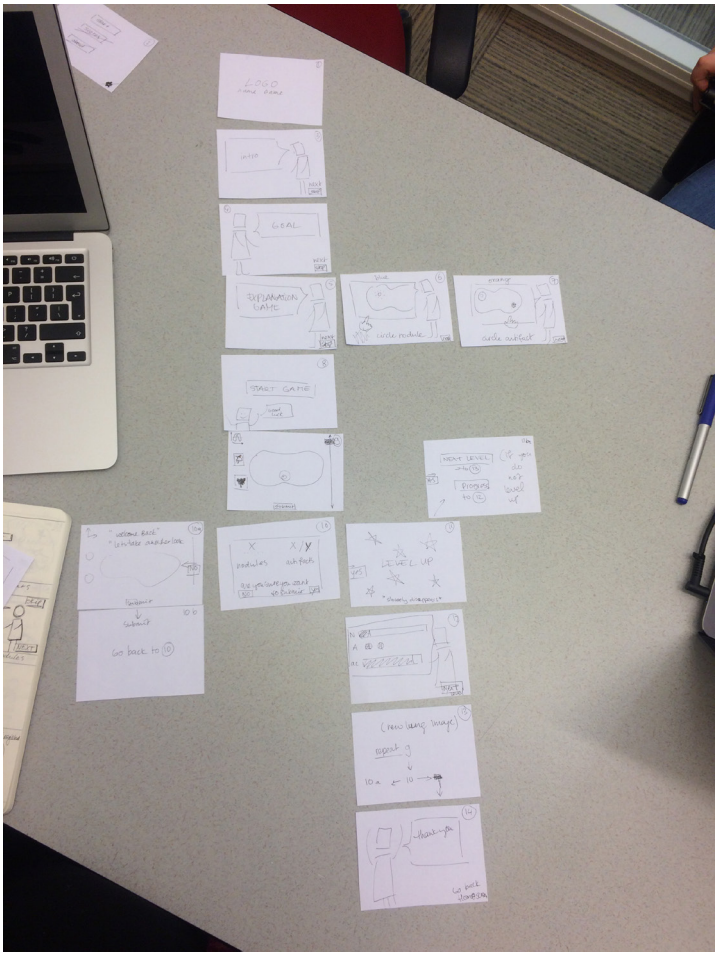


Fig III.C.4'Paper Prototype'

D. Feedback

The sliding bar is not immediately detected by people who test out the game.
People do not understand the distinction between the blue and orange button.
Artifacts were often hard to distinguish.

Feedback takes place close to action.
Feedback should happen in action.
Feedback system that gives the user trust and responsibility
Reconfirm with people from time to time.
Action vs Feedback button, mark some distance between the buttons.

People were reading the instructions carefully.
How to play has a very small font, hard to read for some.
Some were lost in instructions - provide 'do it instructions' to validate the player.

There should be something to make corrections and remove errors. Show people what nodules they missed.

It misses a trial game. Where you can get feedback and enboarder to try something.
There is missing a check task. How do people learn to play?
explain what a nodule is/ mark a nodule/ explain buttons/ move slider
how to remove input
give a good/ not good example

More screen can be used, your screen is very valuable!
Screen space is precious. Go for full screen.
Presentation wise: use one phone.

People, they play for themselves.
How many people are left to save? (ALS)
You give and get information. When are you training the machine and when are you training yourself.

Explain goal more clear - locating cancer and help/do research.
Help researchers. Feeling of contributing.

The game is too playful for the subject.
The design looks childish - "Is the target group children?"

How do we validate the information?
The game is displaced for grownups.

Technical vs psychological aspect.
(look at PHD from Pierre.)

Trustable information: holding to 'tap' is a good interaction.
Fat fingers is a problem, you do not see where you tap.

IV. Concept Platform

A. Wireframe

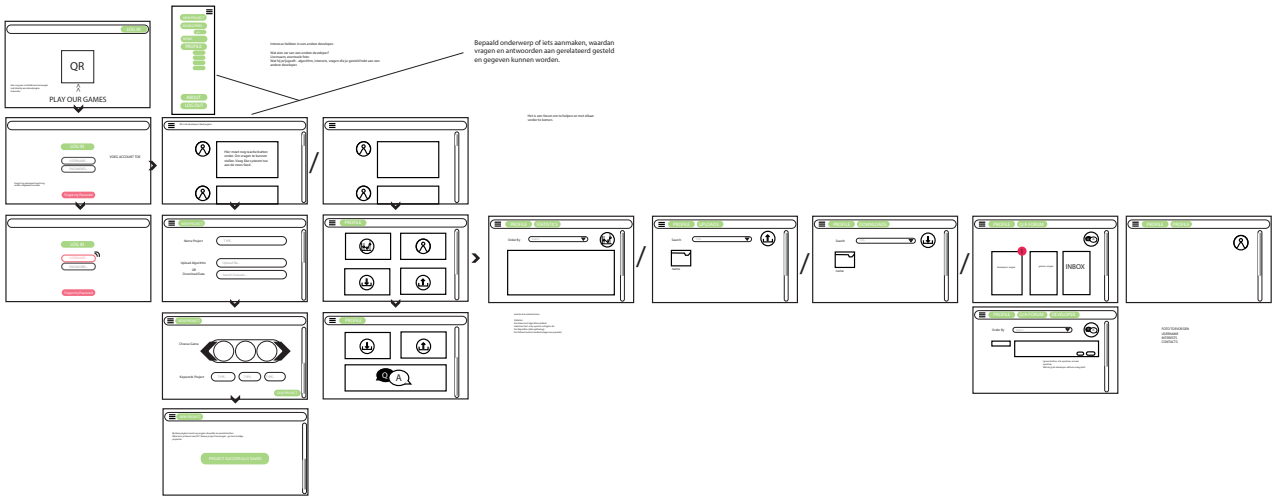


Fig IV.A.1 ' Wireframe'

B. Application Platform

Fig IV.B.1 'Application platform'

V. User Test

A. Surveys

Link to Survey 1: Group without explanation of the concept
https://drive.google.com/open?id=146dTVCtQUS5ejuWLrcnmDILr8Lji-GhuUK7ChDcD-ts

Link to Survey 2: Group with explanation of the concept
https://drive.google.com/open?id=1fRghlXg9pRU6Ssa9C_BomdhC3s5zzn1WGYleCxK8P2c

Tasks User Test 'IMAG/e' whilst playing the game (see Appendix IV.C)
1. Find a nodule and tag/circle it.
2. Scroll through a whole lung.
3. Find all artifacts in one scan.
4. Remove a tag/circle you have placed.
5. Move a tag/circle from its original place.
6. Search for help.
7. Cancel the game
8. Finish a game

B. Results

Link to Results Survey 1: Group without explanation of the concept
https://drive.google.com/open?id=146dTVCtQUS5ejuWLrcnmDILr8Lji-GhuUK7ChDcD-ts

Link to Results Survey 2: Group with explanation of the concept
https://drive.google.com/open?id=1fRghlXg9pRU6Ssa9C_BomdhC3s5zzn1WGYleCxK8P2c

VI. Final Design

A. Code

Link to github for the code of our final application:
https://github.com/ScrambledFox/IMAG-e-2017-2018

B. Visuals

Fig VI.B.1 'Logo NoDe'

Fig VI.B.2 'Game Guide Doctor, GGD'

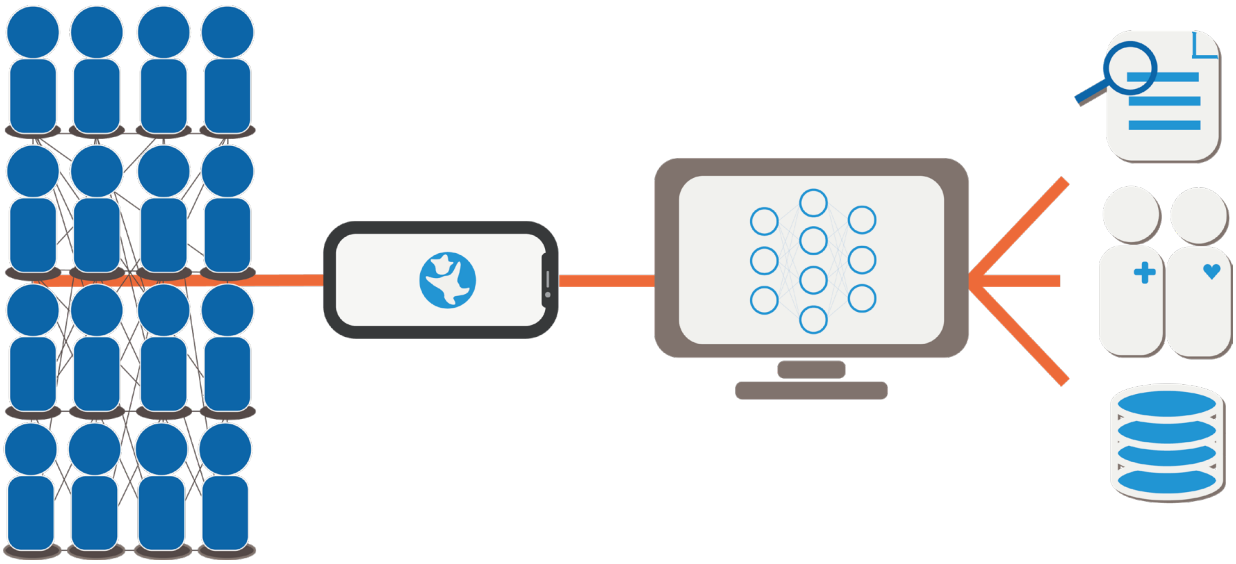


Fig VI.B.3 'Data Process'

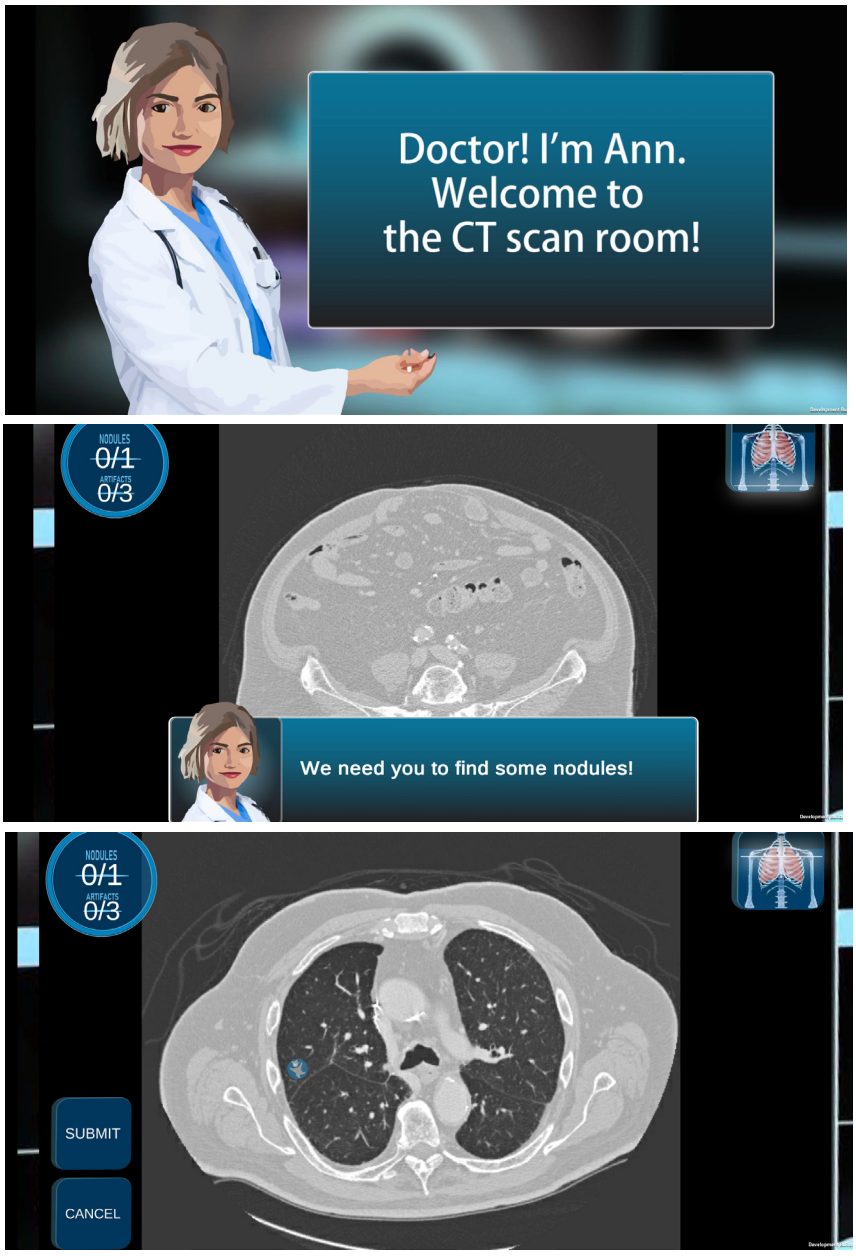


Fig VI.B.4,5,6 'Screens final game'

C. Game

node.jorislodewijks.nl
Click on download for the game

Only for android phones

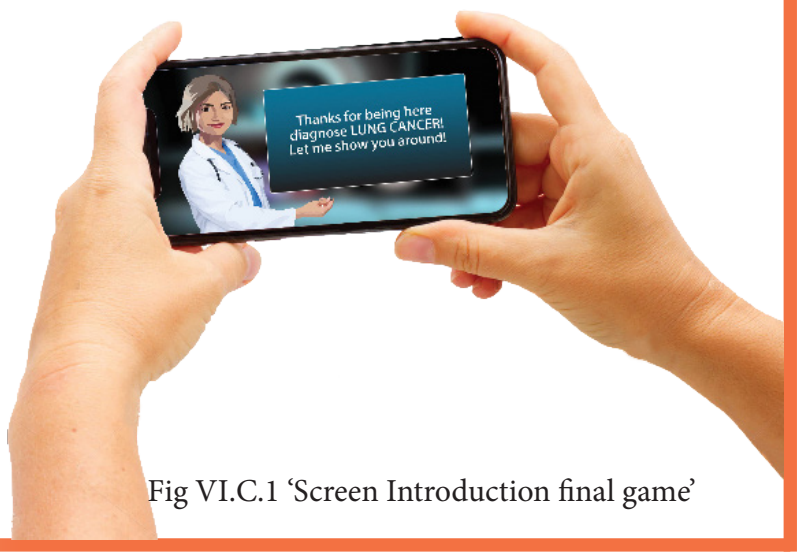


Fig VI.C.1 'Screen Introduction final game'

VII. DemoDay

A. Posters

B2 / Project 2 / Design for Creatives
Nodule Detection through Gamification

SCAN ME
SCAN FOR GAME

Nodule Detection through Gamification
In collaboration with the Medical Image Analysis Group of Eindhoven, we looked at a succesful interface for annotating medical images. In this project we use crowdsourcing as a tool to annotate images of lungs and provide training data for machine learning. The application we made is a game called NoDe which translates the actions of the user to data for the computer. NoDe provides not only a fun game, but is also educational, simplistic and guiding. Therefore crowd sourcers with or without prior medical expertise can play this game.

Our goal is to provide larger datasets of annotated lung images for machine learning. Therefore, with this knowledge, patients can be diagnosed in an early stages. This is beneficial for the patient because an early treatment increases the survival rate.

Student(s): A.C.Bloem, G. Chen, A.J.Lodewijks, N.Smolenaars

Project Coach: Dr. V.J.Khan,Prof. ir. dr. J.B.O.S.Martens

Client: V. Cheplygina

Fig VII.A.1 'A4 - project information'

Nodule Detection through Gamification

in collaboration with Medical Image Analysis Group Eindhoven

ABSTRACT

In collaboration with the Medical Image Analysis Group of Eindhoven, we looked at a succesful interface for annotating medical images. In this project we use crowdsourcing as a tool to annotate images of lungs and provide training data for machine learning. The application we made is a game called NoDe which translates the actions of the user to data for the computer. NoDe provides not only a fun game, but is also educational, simplistic and guiding. Therefore crowd sourcers with or without prior medical expertise can play this game.

GOAL

Our goal is to provide larger datasets of annotated lung images for machine learning. Therefore, with this knowledge, patients can be diagnosed in an early stages. This is beneficial for the patient because an early treatment increases the survival rate.

DATA PROCESS

To the right you find the process the data will go through in order to contribute to the medical research, experts and its database. The input of the crowdsourcers via the app will provide the computer with data it can learn from. Therefore our app is the translator between the actions of the user and the knowledge for the computer. Through machine learning, a computer will eventually be able to detect nodules, even in early stages, on its own using this self learning algorithm. The algorithm can then be used to improve research, make early diagnoses and improve medical datasets.

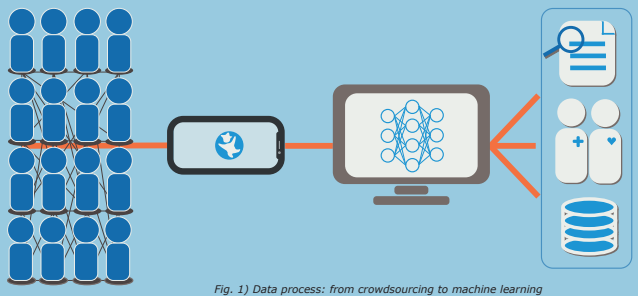


Fig. 1) Data process: from crowdsourcing to machine learning

METHODS

7 Participants tested out the second version of the game. These participants were divided over two groups. Each participant was asked to complete eight tasks. One group performed these tasks with an explanation of the concept and the other group was asked to complete the tasks without any explanation.

Fig. 2) User test: finding a nodule vs finding an artifact

The results of this user-test were that only two out of seven people found a nodule, of which one participant by accident. No one really knew what a nodule was. However almost everyone found the artifacts hidden in the scan. Therefore they did understand the interface, but lacked information about the characteristics of a nodule.

NODULES

Lung nodules are known as spots on the lung which can be seen with a CT-scan or an X-ray. One in every 500 images shows a lung nodule. This does not mean that you have cancer. First it has to be determined whether the nodule is benign or malignant. Most nodules are less than 10 mm small and are not vdangerous. The moment a nodule starts growing or is already quite large, it could be malignant. Early diagnosis can increase the survival rate.

Fig. 3) CT-scan of lung

Fig. 3) CT-scan of lung with nodule

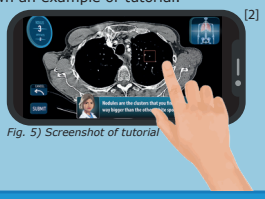
FINAL DESIGN

Our final design uses gamification because research has shown 'how implementations can ncrease crowdsourcees' motivation and participation in crowdsourcing.' [1]

With NoDe we have used the game element 'hide and seek'. Participants are stimulated to search through the lungs to find nodules and hidden artifacts. In every image one or more artifacts is/are hidden and it is up to the user to find these artifacts to improve their own accuracy score. Not only the artifacts but also the found nodules contribute to this.

Furthermore our game contains an interactive introduction, because our user tests have shown that people lack visualization and knowledge of nodules and that they perform better after having shown an example or tutorial.

Fig. 4) Doctor holding an artifact



[2]

Fig. 5) Screenshot of tutorial

FUTURE

In the future we would like to go from Nodule Detection to Nodule Classification. For research and diagnosing patients it is important to know whether a nodule is benign or malignant, aside from the location.

Aside from the game, a platform is needed to collect all the data in one place, ready for use. These platforms exist and a link has to be made between them and our game.

REFERENCES

[1] Morschheuser, B., Hamari, J., & Koivisto, J. (2016, January). Gamification in crowdsourcing: a review. In System Sciences (HICSS), 2016 49th Hawaii International Conference on (pp. 4375-4384). IEEE.

[2] Cancer Imaging Archive. (2018) Reftrieved from https://www.cancerimagingarchive.net/nbia-search/?Collection-Criteria=LIDC-IDRI

Design for Creatives - DDP003

Coaches:
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Dr. ir. V. Cheplygina
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N. Smolenaars 1230056

IMAG/e

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Fig VII.A.2 'Informational Poster'

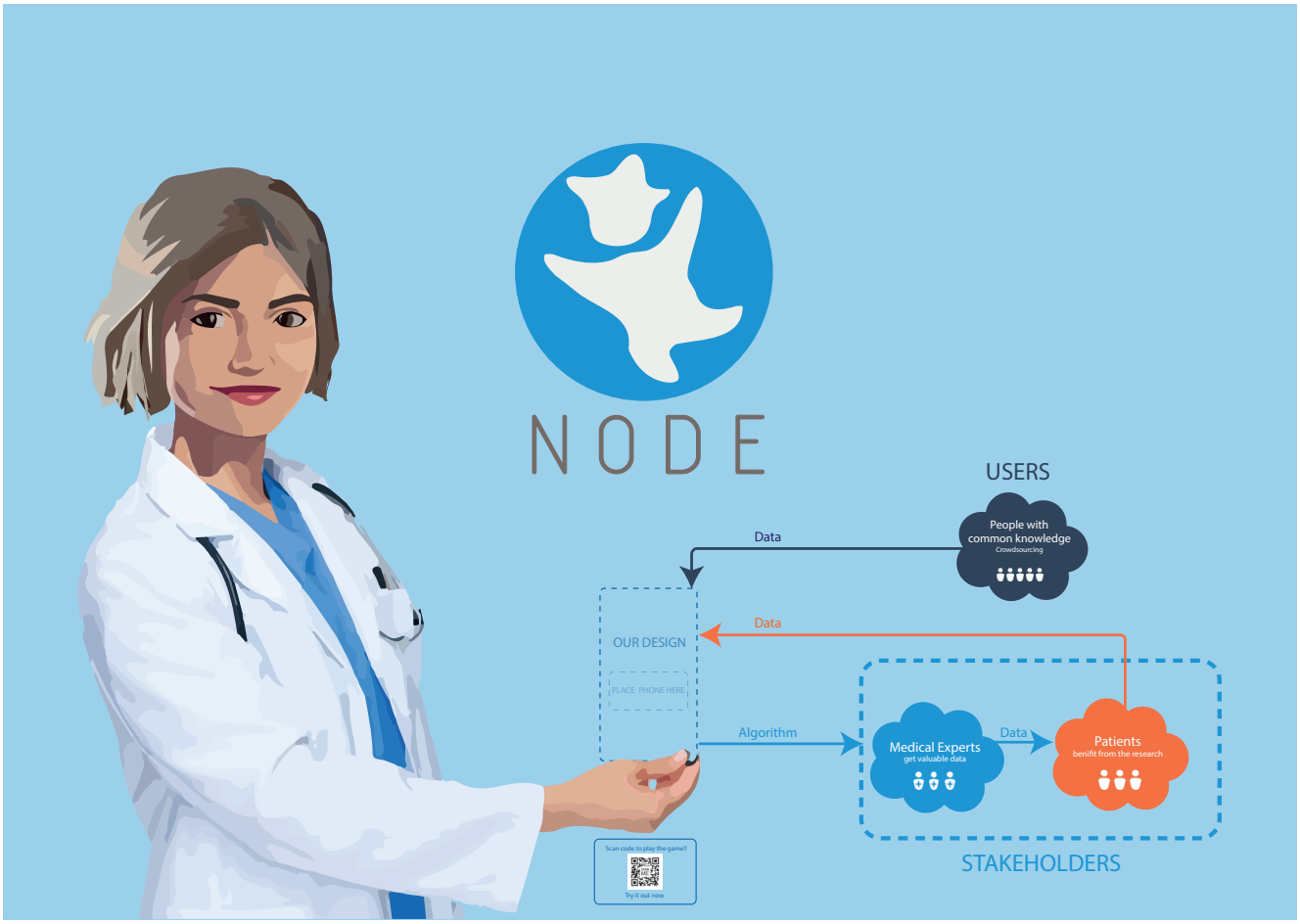


Fig VII.A.3 'Attractive/Interactive Poster'

B. Pitch

Nowadays we have many advanced devices for medical imaging. However, the waiting time to get diagnosed can still take up to a couple of weeks. Which leads to a lot of worrying for the patient and takes too much time away from the medical experts. Luckily, computers can help. By using machine learning algorithms, valuable time is saved.

The only problem is, for this to work, the algorithm requires a lot of data. And that's where we step in. With help of crowdsourcing, a computer can learn how to annotate the medical images by training data from the crowdsourcers.

Our game translates behavior of users to data for the computer.
This way a lot of people can help with medical image annotation instead of only the medical experts.

Our goal is to make medical research more open to the world and use the strength of the masses to get results!

Each one of us can make a difference, together we can make a change!

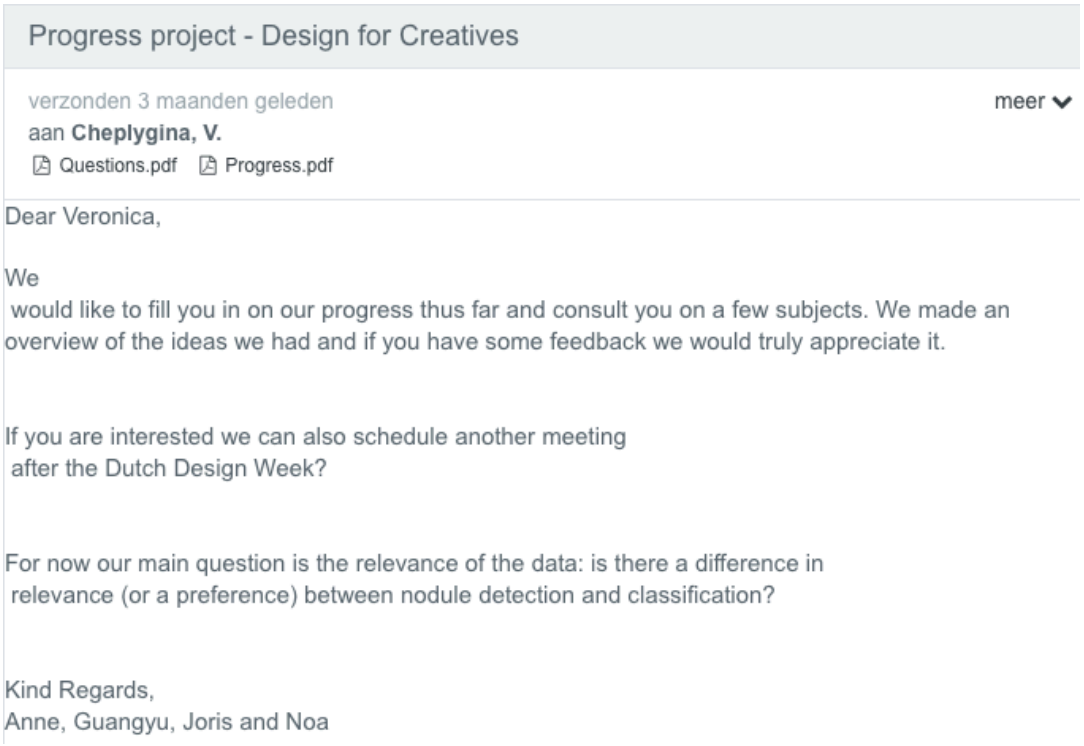
C. Presentation

Fig VII.C.1,2 'Photos DemoDay'

Fig VII.C.3,4 'Photos DemoDay'

VII. Log Client

A. Email



Progress project - Design for Creatives

verzonden 3 maanden geleden meer

aan **Cheplygina, V.**

Questions.pdf Progress.pdf

Dear Veronica,

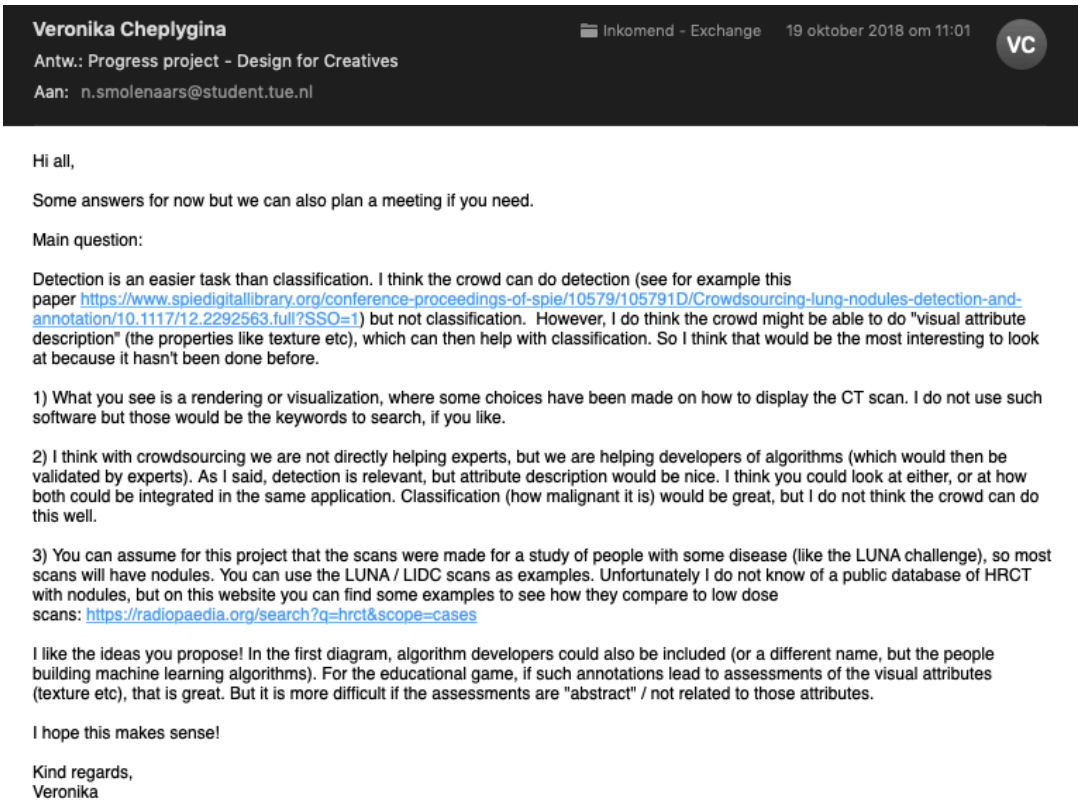
We would like to fill you in on our progress thus far and consult you on a few subjects. We made an overview of the ideas we had and if you have some feedback we would truly appreciate it.

If you are interested we can also schedule another meeting after the Dutch Design Week?

For now our main question is the relevance of the data: is there a difference in relevance (or a preference) between nodule detection and classification?

Kind Regards,
Anne, Guangyu, Joris and Noa

Fig VII.C.1,2 'Email to Veronika'



Veronika Cheplygina Inkomend - Exchange 19 oktober 2018 om 11:01 VC

Antw.: Progress project - Design for Creatives

Aan: n.smolenaars@student.tue.nl

Hi all,

Some answers for now but we can also plan a meeting if you need.

Main question:

Detection is an easier task than classification. I think the crowd can do detection (see for example this paper https://www.spiedigitallibrary.org/conference-proceedings-of-spie/10579/105791D/Crowdsourcing-lung-nodules-detection-and-annotation/10.1117/12.2292563.full?SSO=1) but not classification. However, I do think the crowd might be able to do "visual attribute description" (the properties like texture etc), which can then help with classification. So I think that would be the most interesting to look at because it hasn't been done before.

1) What you see is a rendering or visualization, where some choices have been made on how to display the CT scan. I do not use such software but those would be the keywords to search, if you like.

2) I think with crowdsourcing we are not directly helping experts, but we are helping developers of algorithms (which would then be validated by experts). As I said, detection is relevant, but attribute description would be nice. I think you could look at either, or at how both could be integrated in the same application. Classification (how malignant it is) would be great, but I do not think the crowd can do this well.

3) You can assume for this project that the scans were made for a study of people with some disease (like the LUNA challenge), so most scans will have nodules. You can use the LUNA / LIDC scans as examples. Unfortunately I do not know of a public database of HRCT with nodules, but on this website you can find some examples to see how they compare to low dose scans: https://radiopaedia.org/search?q=hrct&scope=cases

I like the ideas you propose! In the first diagram, algorithm developers could also be included (or a different name, but the people building machine learning algorithms). For the educational game, if such annotations lead to assessments of the visual attributes (texture etc), that is great. But it is more difficult if the assessments are "abstract" / not related to those attributes.

I hope this makes sense!

Kind regards,
Veronika

Fig VII.C.1,2 'Email from Veronika'

B. Meetings

27-09-2018
31-10-2018
18-12-2018
8-01-2019

C. Feedback

“I really enjoyed the project. You guys brought interesting ideas and were enthusiastic about Medical Imaging. That was great. I apologize for not being 100% present, due to my busy schedule. But emailing went always quite fast.

I would still like something to share and show other people, but also for in the future. The final app or the report would be nice. Furthermore I think it is a good idea to make a video with narration of how to play the game. This can also be done after the report is due.

I find the interaction with the fingers not difficult, but you have to figure it out yourself. It does not go natural. The game element is quite nice, but it would be even better when you can get points or see your score over all the games, not just one.

Later on I can perhaps work with levels of difficulty. A master student of mine works different projects but wants to move towards nodule detection and classification. This is great groundwork.

As for a platform, I am still searching. Because I would really like to have a location for the made applications. Now they are finished but not usable.

It is impressive that anyone, with an android phone, can install the game. To work on a higher goal together is a nice vision”