Research Proposal, Project 3-1

Department of Data Science and Knowledge Engineering, Maastricht University

25/09/2020

Title of Proposal: Identifying a fetus's body from ultrasound images with the help of artificial intelligence

Customer: BabyWatcher

Coordinator: Katharina Schüller, Rico Möckel

Duration: September 2021 – January 2021

	Participant name	Participant ID
1	Zain Farhah	i6193405
2	Boris Borisov	i6211839
3	Emery Karambiri	i6220931
4	Liam Thomassen	i6175948
6	Viet Ha	i6194619

Contents

1 Excellence

1.1 Motivation, context, problem statement

Author(s): Zain Farhah
Internal reviewer(s): Boris Borisov

According to the UN, 385 000 babies are born each day which leads to the fact that a lot of women are pregnant and most of these women want to have a great pregnancy experience. This experience includes visits to the doctor for the purpose of checking on the baby's health and even seeing the fetus using the ultrasound machine. Unfortunately, the process of seeing the baby and taking a picture only lasts for a few minutes and these few minutes are not enough for some parents.

Babywatcher offers a baby ultrasound for home experience. This gives parents the chance to spend more time with their baby however, the parents usually do not know what they are looking at. It is really hard to know, as an inexperienced parent, where the head, hands, feet, and other body parts are.

In this project, we aim to develop an AI that will be able to help the parents know what they are looking at. This AI will utilize different image preprocessing techniques that will remove noise from the ultrasound images. In addition to that, we will be using various machine learning algorithms that will help guide parents as they do the ultrasound by drawing a box or pointing out whatever feature the parent wants to see in their ultrasound image.

1.2 Scientific and technological objectives

Author(s): Zain Farhah
Internal reviewer(s): Boris Borisov

The Babywatcher AI will help parents make sense of all the ultrasounds that they will see by making use of various machine learning algorithms while keeping all the ethical issues that may arise from using the BabyWatcher AI. To achieve the goals of this AI, the main goals have been broken down into several Specific, Measurable, Achievable, Realistic and Timely Objectives that mutually benefit each other. KPIs have been defined for each objective to measure.

Objective O1: Help parents understand obstetric ultrasounds	Addressed in Task <add task numbers>
S.M.A.R.T. Justification	The main goal of BabyWatcher AI is to be able to pinpoint where certain body parts of the fetus are in the image. The AI will draw bounding boxes around a wanted feature and this will guide the parent to know where to look when looking for that feature or body part
KPIs	KPI 1.1: Better understanding of an obstetric ultrasound image by a parent (this is assessed by asking some parents to use the technology without guidance and see what they understand from the ultrasound image)

Objective O2: Find the best noise cancellation technique for the ultrasound images	Addressed in Tasks 4,5 and 6
S.M.A.R.T. Justification	In order for the BabyWatcher AI to correctly classify the images, we need to make sure that the images being classified are clear enough or almost noise-free. To do that, some image processing techniques need to be applied to all the images before the classification step.
KPIs	KPI 2.1: This will be assessed by measuring the accuracy of the prediction of the AI (we aim at accuracies above 70%).

Objective O3: Find the best machine learning algorithm	Addressed in Task 6
S.M.A.R.T. Justification	The BabyWatcher AI will be pointing out the key features, specified by the user, in the image shown to the user. For this, we will be using different machine learning algorithms to evaluate which one works best in our case.
KPIs	KPI 2.1: This will be assessed by measuring the accuracy of the prediction of the AI (we aim at accuracies above 70%).

1.3 Requirements

Author(s): Boris Borisov
Internal reviewer(s): All members

1. **Programming languages**

    i. Python will be used for machine learning algorithms. This programming language has the advantage of a huge variety of libraries used in the field of Artificial Intelligence
    ii. The user interface will be based on the company's software. This will help us adapt faster to the needs of the client and the company's design choices.
    iii. The user interface might contain different features with respect to the period that the woman is pregnant i.e. (10-15 weeks, 15- 30 weeks etc.)

2. **Data**

    i. The first batch of data, approximately 300 images will be provided by the company. This data will be mainly sorted with respect to different features i.e., a number of babies, gender, recognize heart, recognize spinal cord, etc.
    ii. The project team will meet with the manager of the company and medical experts to professionally label images, in order to gather a sufficient amount of images for our project.
    iii. An ideal number of labeled images is at least 6,000. It is important that our data contains both good and bad images so that it has some noise so that our bot will be robust.

1.4 Concept and approach

Author(s): Boris Borisov
Internal reviewer(s): All members

Our aim is to identify the "10 most important features" of any non-medical ultrasound pictures i.e. spinal cord, heart, eyes etc. We plan to use Deep Neural Networks since research shows that this technique results in accurate recognition. On the other hand, we try to gather as many data images as we can. We will label them manually with the help of medical experts of Maastricht hospital and Leiden hospital. Moreover, the fact that we have such a large dataset shows that a simple Machine Learning algorithm will not be successful so we will use DNN. In terms of User Interface, we will use the existing UI of the company which will be really useful and the choice of design of the company will be satisfied.

1.5 Work so far

Author(s):
Internal reviewer(s):

So far, we have gathered part of the labelled data and done the research for the implementation. We will perform image tagging on the data provided from the company.

(TODO GIVE MORE DETAIL)

1.6 Ambition

Author(s): Boris Borisov
Internal reviewer(s):

Our success is defined by implementing a State-of-the-Art Deep Learning algorithms using the available data.

We would like to bring ease of use and clarity to this innovative product that brings ultrasounds out of the hospital into our homes. Furthermore, implementing a 3D visualization of the baby would be a good addition for the company.

1.7 Related Work

Author(s): Emery Karambiri

Internal reviewer(s):

There are not many papers to be found about identifying features of a fetus in an ultrasound that don't focus on the medical aspects.

Projects & publications	Connection to and differences with regard to our project
Computer Vision/Deep learning	
Body Detection with Computer Vision by Instrument [1]	Computer vision basics: HOG and Haar Cascade implementation.
A review on ultrasound image pre-processing, segmentation and compression for enhanced image storage and transmission	We use these pre-processing techniques on the ultrasound images to facilitate the analysis of the AI in spotting wanted features.
Artificial Intelligence in Obstetric Ultrasound: An Update and Future Applications [2]	CNN and ANN are used to identify limbs, facial structure, and abdominal organs.

2 Impact

Author(s): Liam Thomassen, Viet Ha
Internal reviewer(s): Boris Borisov

2.1 Societal impact

Improving health and wellbeing of pregnant women
Pregnancy, especially the first time, can be a quite challenging time in life for a woman. Pregnant women visit the emergency room more than twice on average with concerns about their baby's well-being. The Babywatcher solution provides vital information to healthcare providers to determine if a baby is healthy, helping expectant mothers have peace of mind at home and avoid unnecessary visits to the emergency room. The fetus development and health of the baby are among the most worries. Knowing about the well-being of the baby in the comfort of their own home allows women to have more relaxing time and improve their quality of life during pregnancy. Early baby images also create and flourish emotional relations between the mom and the baby.
Facilitate the cooperation between pregnant women and healthcare professionals
During the COVID time, challenges propose alternative prenatal care resolution. Mobilizing telemedicine provides virtual visits and distant support alongside in-person consultations. Mobile medical devices enable digital information sharing with healthcare professionals for clinical consultation, follow-up, and documentation. Using these devices offers advantages in patient care and involvement, with possible benefits for clinical outcomes and cost-effectiveness.
Support healthcare professionals
An ultrasound image recognition AI can support the monitoring of an unborn baby, diagnosing a condition or guide a surgeon during certain procedures.

2.1 Economic impact

Market pioneer
Babywatcher has raised 1 million euros. The start-up from Maastricht is offering a device that enables pregnant women to make fun ultrasounds themselves – the first in the world, according to the company, based on the Brightlands Health Campus. The recent investment round was concluded by the current shareholders, which include the province of Limburg’s regional development agency Liof, the Limburgian Business Development Fund (LBDF) and a new investor, KIKK Capital. The money raised will be used to accelerate growth within Europe.
Domestic and Foreign market
According to the company, its device is FDA and WHO compliant, and it has been approved by Health Canada and TÜV Rheinland.

The Babywatcher can be rented for different periods of time or bought. The device is available in 12 European countries and the USA, but the focus is on the Netherlands, Germany, and France. Three years after the start, it has reached 450,000 ultrasounds made.
Current and potential customers
The product's first appeal is pregnant women, who are excited to see the fetus, and women with difficult pregnancies, who experienced distress before. Tech-minded mothers and fathers are likely to be early customers. In the connected world, doctors and health professionals may use it to remotely monitor the baby's well-being and give better pregnancy consultations.
Potential market size
By increasing the product's usability, it could make using BabyWatcher less daunting therefore more people with little to no medical knowledge (or even technological knowledge). It could encourage them more to get a BabyWatcher. The stable birth rate also supports a substantial market.

2.2 Research impact

Fetal ultrasound images can help doctors determine fetal growth, health, and development furthermore the uterus is checked for any abnormalities. Image recognition may help future obstetricians spot, identify or diagnose certain afflictions such as birth defects in the first trimester. Since most often ultrasound imaging is a noninvasive operation that is safe it is also used in other instances than pregnancies. Examples of these instances are diagnosing gallbladder disease, evaluating blood flow, examining breast lumps and detecting genital and prostate problems. Again image recognition on these ultrasound images can help correctly diagnose patients. Although our main focus for this project is to help bonding between the new baby and its parents, future medical implications could simplify and help doctors.

There is constantly new image recognition software being created that could improve accuracy over a previously used algorithm. In addition improvements to ultrasound equipment will improve image clarity and quality. Since there hasn't been much previous research done on this topic, as such there is still lots of room for improvement.

2.3 Other impact

Cultural impact
Since the business started selling products that were only used by medical experts previously, customers can now perform ultrasound imaging from the comforts of their own homes. This allows parents to form a bond with their unborn child much easier and whenever they choose. This results in bonding with the child much earlier than previously. Image recognition is a vital part to help parents classify images that are difficult to interpret. Culturally this could

mean pro-life movements gain more credibility since ultrasound imaging would be more readily available.
Ethical impact
During the 1980s and ‘90s in China, sex selection in unborn babies was common, this came from a belief that males have more value than females through a long history of patriarchy. This operation was performed by using ultrasound imaging to determine the sex of the child however two decades ago this practice was forbidden in hospitals. Granted that the company wishes to market the ultrasound device worldwide, societies that are still patriarchal may have this issue of sex selection or in China this problem may return by giving them the ability to determine the sex of the fetus using image recognition.

3 Implementation

3.1 Gantt chart

Author(s): Zain Farhah
Internal reviewer(s):

Group 01 Planning		Start Date: 30/09/2021				Phase 1							Phase 2							Phase 3						
						Week 1	Week 2	Week 3	Week 4	Week 5	Week 5	Week 6	Week 1	Week 2	Week 3	Week 4	Week 5	Week 5	Week 6	Week 1	Week 2	Week 3	Week 4	Week 5	Week 5	Week 6
	TASK																									
1	Main Tasks	Start	End	Who	Days																					
	Collect Data																									
	Check Requirements																									
	Research on preprocessing techniques																									
	Research on machine learning algorithms																									
	Creating a UI Prototype																									
	Research Questions																									
	Implementation of the AI																									
	Connecting the AI with the UI																									
2	Other Tasks																									
	Documentation of the AI																									
	Testing																									
	Experiments																									
	Analysis																									
	Cleaning the code																									
	Scientific Presentation 1																									
	Scientific Presentation 2																									
	Scientific Presentation 3																									
	Business Presentation																									
		Code and Report Deadline																								
		Presentation Deadline																								

3.2 Work plan

Author(s): Zain Farhah
Internal reviewer(s):

Task 1: Gather labelled data
To train our AI, we will need labelled data for each body part we aim to recognize in the ultrasound. Babywatcher already has a large amount of images, however they are not labelled. To do this task, we will collaborate with them to label the images together with some experts.
Task 2: Check if there are any specific requirements
Before any research, we will need to check if they have any requirements regarding the technologies that we are allowed to use. This includes the programming languages and other platforms.
Task 3: Create the UI of Extend the current UI
We plan to extend the already existing UI by adding the feature we will need to help parents that are not familiar with this type of technology to easily navigate through the UI.
Task 4: Research on potential methods or approaches
Before implementation, we will need to go through the possible approaches we can take to reach a good result.
Task 5: Implementation of image preprocessing techniques
After the research phase is done, we will move onto implementation which will first be implementation of the image preprocessing techniques. These techniques will work on removing noise in the ultrasound images.
Task 6: Implementation of machine learning algorithms
After we have cleaned our data, we will move onto implementing the machine learning algorithms that will work on classifying the body parts we plan to recognize. (We will first start with the easier body parts like the head, legs, etc..)
Task 7: Testing
After implementation is done, we will move into the testing phase to see if the code runs as intended.
Task 8: Experiments
In this task, we will perform experiments with the aim of answering our research questions.
Task 9: Analysis of the results
After all experiments have been done, we will need to make sense of the data collected and so we will analyze the results in order to use them to answer our questions.

3.3 Milestones

Author(s): Zain Farhah
Internal reviewer(s):

No.	Milestone name	Involved tasks	Date	Description
1	Planning Phase	1 & 2		Data will be ready and requirements will be clear
2	Design Approval	3		The UI will be presented to BabyWatcher and they will approve if it meets the requirements
3	Research Done	4		The research will be done and we will know what approaches we will be implementing
4	Implementation Phase	5 & 6		Start implementation in code
5	Testing Phase	7		Test all approaches to see if they work as intended
6	Experiment and Analysis Phase	8 & 9		Experiments will be done and results will be analyzed. We will be able to answer the research questions

3.4 Deliverables

Author(s):
Internal reviewer(s):

No.	Name	Lead	Type	Dissemination Level	Delivery Date
RE: Document, report | DEM: Demonstrator, pilot | DEC: Websites, press & media actions, videos, etc. | OTH: Software, etc. Dissemination PU = Public | CO = Confidential.					
1	Project plan				
2	Research Questions				
3	Prototype				
4	Experiment Results				

5	Final Product				
6	Business Presentation				
7	Scientific presentation				

3.5 Risk management

Author(s): Boris Borisov
Internal reviewer(s):

Risk	Prob	Impact	Mitigation Plan
Data risks			
Lack of data	Medium	High	We will try to achieve as high accuracy as we can with the available data.
Not having noisy data	Low	Medium	If this risk is met, we will not have a really nice solution in terms of accuracy, precision, optimal results etc.
Management risks			
Insufficient communication	Low	High	Communication channels are used i.e. WhatsApp, Facebook and emails so that this issue is avoided.
Not having meetings to keep up the organisation	Low	High	Weekly meetings are made in order to keep a perfect pace of the project.
Implementation risks			
Bad performance	medium	High	We did some research in order to apply the most appropriate algorithms for this task.

4 Concluding remarks

Author(s):

Internal reviewer(s):

<Add your text here>

References

[1] https://medium.com/instrument-stories/body-detection-with-computer-vision-1898cdc6b7d

[2] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8429607/