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**«HIGHER SCHOOL OF ECONOMICS»**  
**FACULTY OF COMPUTER SCIENCE**  
**DEPARTMENT OF SOFTWARE ENGINEERING**

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Facial Recognition and Eye Tracking Application for Evaluating Advertising Content

**Final Document**

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«\_\_\_\_» \_\_\_\_\_ 2021.

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«\_\_\_\_» \_\_\_\_\_ 2021.

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## **1. INTRODUCTION**

### **1.1. Name of the project**

Facial Recognition and Eye Tracking Application for Evaluating Advertising Content

### **1.2. Brief description of the application area**

The project is a web application for evaluating advertising content using deep learning approaches. Evaluation assessed by the application enables users to discover important features, such as the user reactions and eye gazes for each moment in time.

## **2. TEAM**

### **2.1. RESPONSIBILITIES**

Dagyanorov L. will be responsible for Machine Learning models' development and deployment. He will research, implement, and test ML models for eye tracking and emotion recognition. Once those prototypes are ready and tested he will make his best effort to deploy those solutions into the cloud, where they will be easily accessed from the backend.

Kulakov A. D. will create the design of the web app, he will create the front-end part based on his design. Once that is done he will code all the backend parts of the web application. Kulakov A. D. will also support and consult Dagyanorov L. in ML model development. After both website and ML models are finished and deployed, Kulakov A.D. will make both parts work together and test the final version of the system

### **2.2. MATRIX OF COMPETENCES**

Skill	Kulakov A. D.	Dagyanorov L.
Machine Learning	5	4
Python	5	5
Javascript	2	1
Layout creation	3	2
SQL	4	5
NodeJS	2	2
Django	3	4
Backend development	3	4
Frontend development	3	2

Table 1. Matrix of Competences

## **3. PROJECT MANAGEMENT**

### **3.1. Metrics of the product**

In order to evaluate the quality and result of the product and the development process, the following criterias will be used:

- Requirements meet. Whether the final product meets with the customer's desired needs and requirements.
- Deliverability. Whether any project documents and results are delivered in time with quality.

### 3.2. Gantt chart

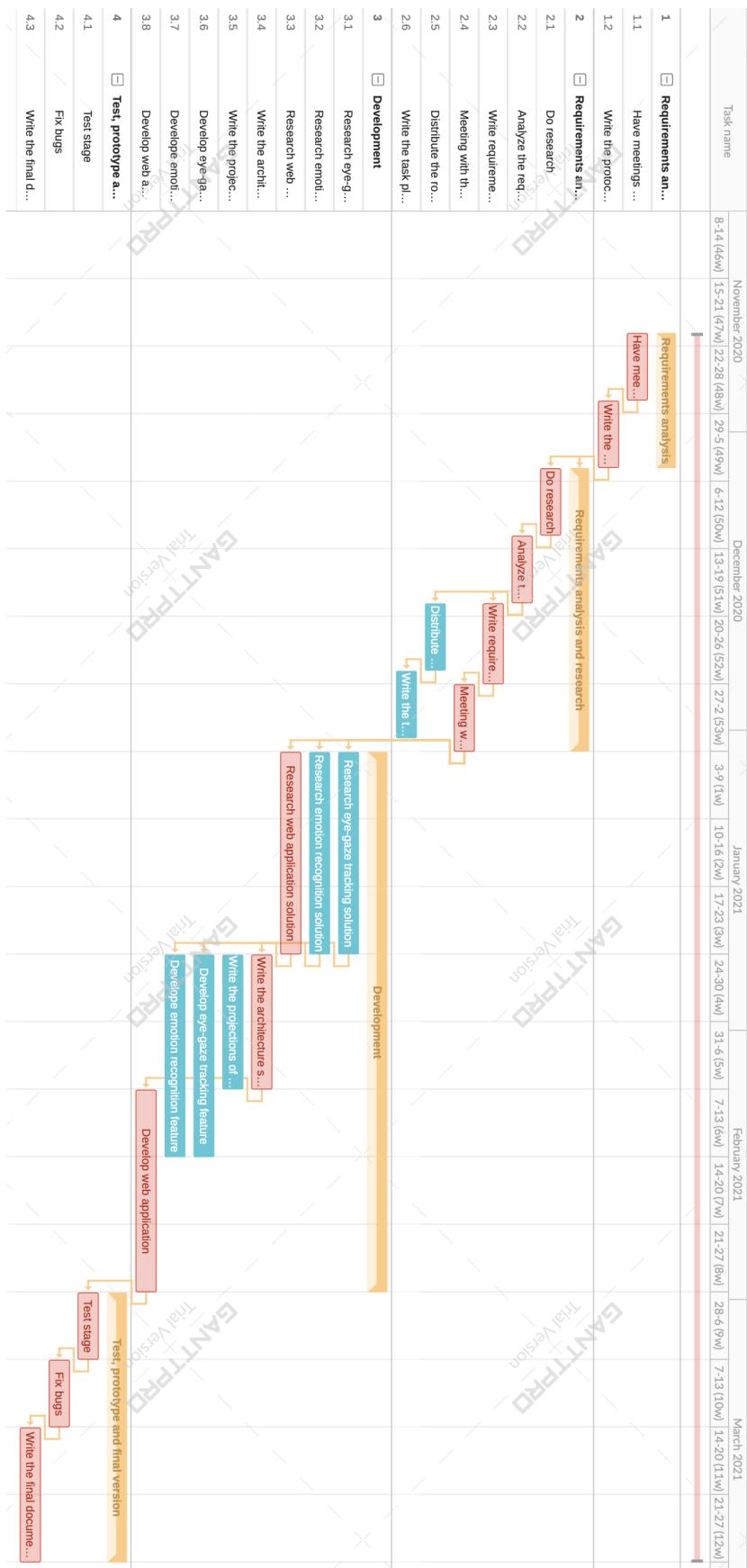


Image 1. Gantt diagram

### 3.3. Used instruments

During the development process of the project, the following instruments were used:

- GanttPro.com to design a Gantt diagram.

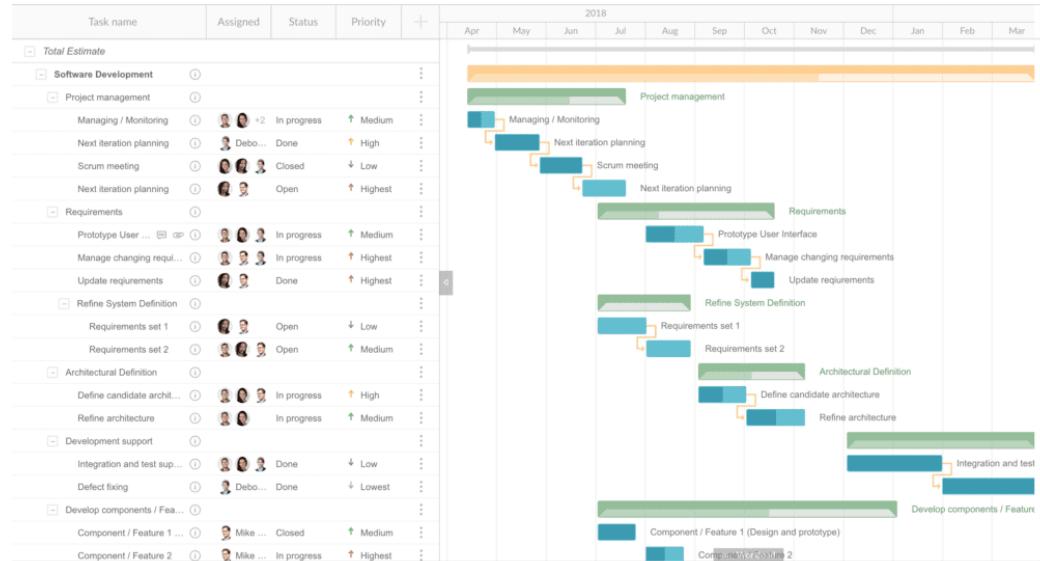


Image. An example view of GanttPro.com

- Google Docs for writing notes and documentations. Google Docs has the advantage of collaborative editing among the team members.

**Apollo 11**

**Summary**

This is a research paper about the Apollo 11 moon mission in which Neil Armstrong, Buzz Aldrin, and Michael Collins landed at Tranquility Base on the moon. The Apollo 11 lunar module, AKA The Eagle, landed on the moon on July 20, 1969. When they landed, the message they sent back to Mission Control was "Tranquility Base here. The Eagle has landed."

**The Spacecraft**

The Apollo 11 mission had three spacecraft: the Command Module Columbia, a Service Module, and the Lunar Module Eagle. Columbia was the only part of the spacecraft to return to Earth.

**Design**

The key NASA spacecraft involved in the Apollo 11 mission were the following: a Saturn V rocket, an Apollo CSM-107 (Command/Service Module) and an Apollo LM-5 (Lunar Module, AKA "The Eagle").

**Command module**

The Command/Service Module (CSM) was one of two spacecraft, along with the Lunar Module, used for the United States Apollo program which landed astronauts on the Moon. It was built for NASA by North American

Image. An example of Google Docs

- Visual Studio Code to write and edit code. Python, JavaScript, HTML and CSS were used as the main programming languages and they have been edited in the Visual Studio Code environment.

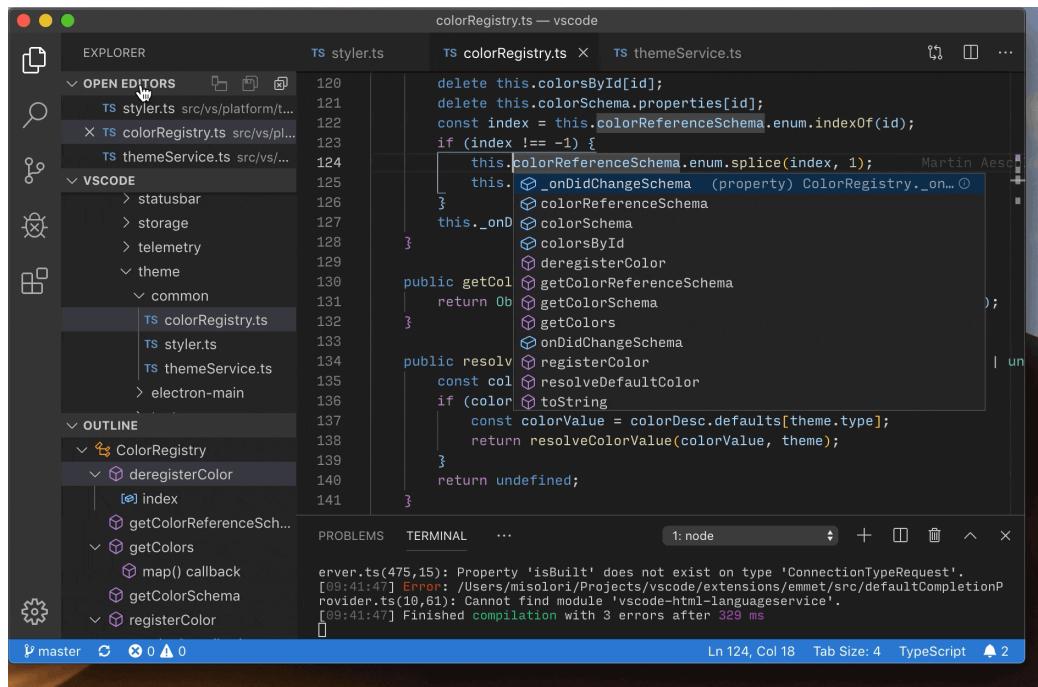


Image. Interface of VS Code.

- Google Chrome Browser is used for testing web application prototypes.

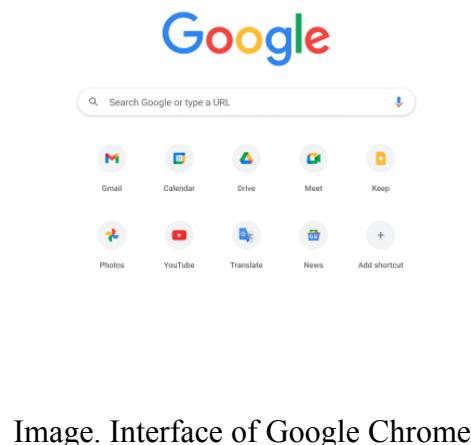


Image. Interface of Google Chrome

### 3.4. Risk analysis

We presumed that several potential risks can occur during the development of the project.

No	Risk identification	Risk impact / likelihood	Risk prevention	Risk management
1	Absence of a team member due to	Major / Moderate	Unable to control	In this case, if it happens, the remaining team member should

	external factors.			analyze all possible resources (time) and modify the workload (Gantt Diagram, Matrix, etc.).
2	Unavailability of a team member due to study overload.	Moderate / Moderate	Team should plan work in advance with additional reserve time.	Team members should analyze all possible resources (time) and modify the workload in order to finish work in time.
3	Can't hand in documents before deadlines	Low / Low	Team should plan work in advance with additional reserve time.	If the deadline has passed, it cannot be managed.

Table 2. Risk Analysis

#### 4. SUBJECT AREA AND PRODUCT DESCRIPTION

##### 4.1. Formulation of the problem

In the traditional way, users are usually asked to fill questionnaires to evaluate any kind of product. However, this method has several drawbacks: “time use - users are not happy with spending their time to evaluate products. And this results in inaccurate data.”; “can’t observe small emotional changes”.

To address this problem, recent developments in deep learning can be applied. The advancements of facial recognition (emotion recognition, eye-gaze tracking) allows us to monitor all reactions toward a product.

##### 4.2. Analysis of the subject area, scope and boundaries of the project

The web application has an advantage of deployment that can be used in anywhere but requires a computer installed with a web browser and a web camera. Any media product (content, such as video, picture and etc.) can be evaluated with the help of the application. We have planned to build a web application which allows us to test/evaluate media products with the features described above.

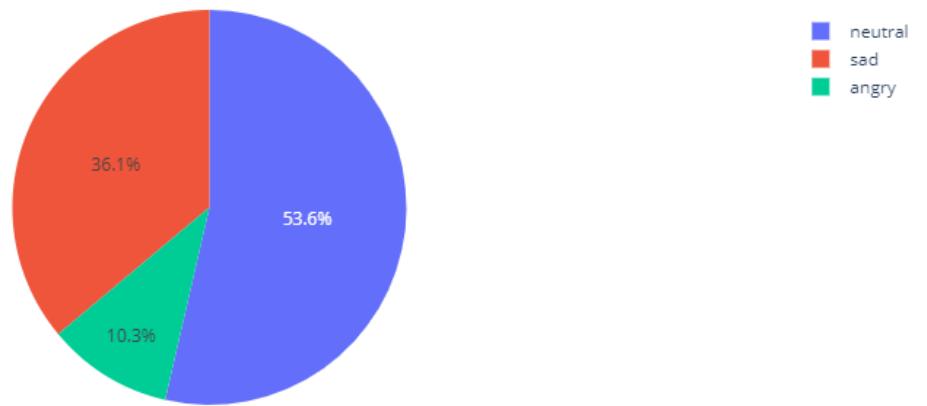
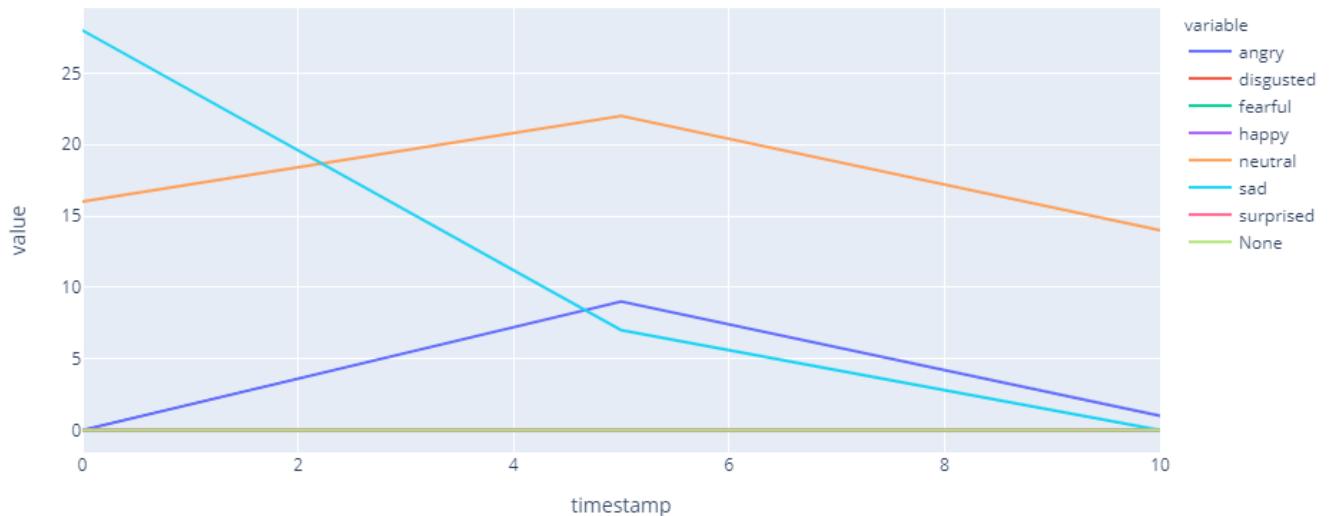
##### 4.3. Application purpose

During the use of the application, a certain add content will be shown on the screen, the application using the web camera will track the user's gaze at any given time, as well as emotions of the user. While testing the element of the product, the application will aggregate all dimensions and finally show the dashboard for the selected video content. As a result, this will make it possible to more effectively test video adds.

##### 4.4. New features provided

In this project, we have proposed a new way to evaluate any video content with a dashboard embedded in the web application. We measure both user emotions and eye gazes during the session and then aggregate this information into the detailed statistical report.

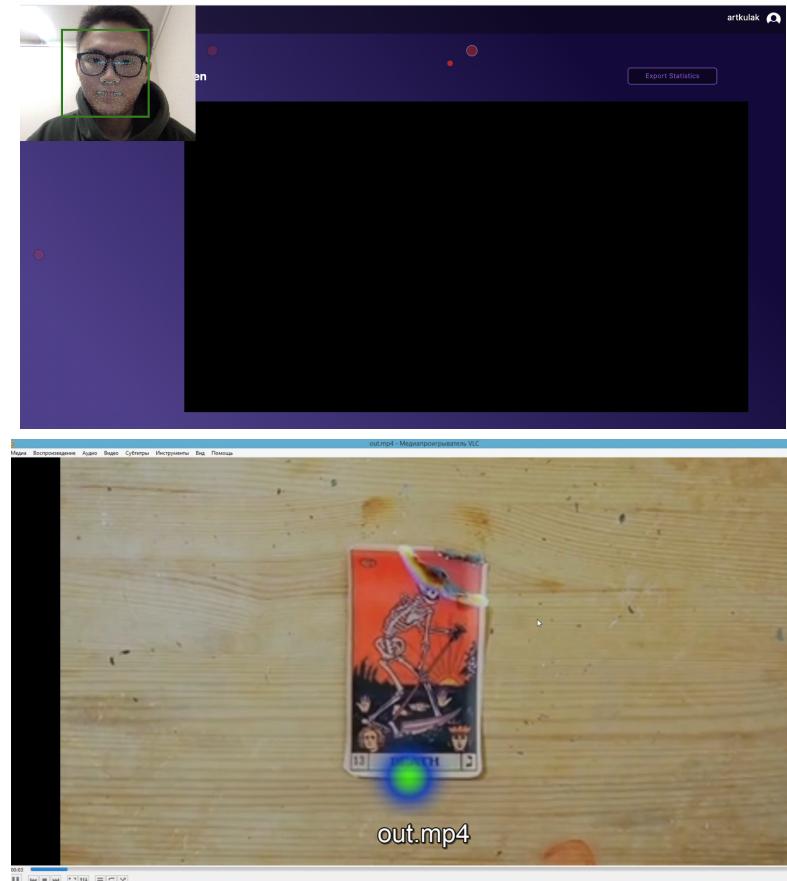
- User Engagement Analysis with various emotion indicators. We evaluate user emotional changes and display on the dashboard



- Implementation of user emotion recognition from the web camera



- Implementation of eye-gaze tracking for each user on the video.



## 5. DESCRIPTION OF THE POTENTIAL USERS

### 5.1. Customer's goal and key stakeholders (Stakeholder Management Matrix)

Stakeholder name	Contact Person	Engagement Strategy	Interest /What is important to the stakeholders? /	Influence /how much influence do they have over the project?/	Impact /how much does the project impact them?/
H. Saleh /customer/	H. Saleh	Weekly discussion through Zoom call	Achieve targets	High, Influential in decision making process	Medium

A. Kulakov /team member, project manager/	A. Kulakov	Biweekly discussion through chat and call	Retain and expand skill level	High	High
D. Lkhagvajav /team member/	D. Lkhagvajav	Biweekly discussion through chat and call	Retain and expand skill level	High	High

In the following part, few questions are asked to the customer in order to clarify all requirements and expected results. Also, to understand the tasks of the customer and who are the key stakeholders.

### **1. Is the application intended for individuals or legal entities?**

The application is intended for both individuals and legal entities who need to conduct effective video content analysis with deep learning.

### **2. Who are the main clients of the company?**

The main clients are the owners of web resources who capture video content on a daily basis.

### **3. Who interacts with the application on the part of the client company (approximate position of the employee, age and level of proficiency in the subject area)?**

The application will be interacted with by a manager who will set up the environment for testers. Age 25-60 years old, confident PC user

The tester will interact with the application, who will be the “user” of the application during advertisement testing. Age 20-40 years old.

### **4. How many users (approximately) will use the application at the same time?**

The application will be installed on the web server. All the testers should be able to access the app via browser.

### **5. What current problems does the developed application / product / service solve? What should the user do with the product / service being developed?**

The application helps to make advertisement evaluation more transparent for the client. Due to the use of machine learning, more video quality assessment tools become available, which has a positive effect on user experience.

## **REQUIREMENTS FOR TOOLS AND TECHNOLOGIES**

The application must be developed as a web application for internet browsers. It requires a computer with an internet browser and a web camera. A browser should support Javascript and need to be updated.

Machine learning models for an application must be developed using Python and deployed to Javascript, then they as separate scripts while the application itself is running. The server for the application must be written in Python and process measurements coming from Javascript frontend models(eye position, emotions) at every moment of time.

## WORK RESULT

Web application for internet browsers. Javascript scripts for running ML models. Python web server for aggregating information obtained during testing. The source code of all modules and scripts was handed over to the customer.

### 5.2. Responsibility Matrix

Project objectives		Date	Responsible	Hours
Machine Learning				
	Research ML solution for eye tracking	2020.11.10~13	Dagvanorov L.	5
	Research ML solutions for emotion recognition	2020.11.15~17	Dagvanorov L.	5
	Implement ML model for eye tracking locally	2020.11.20~12.15	Dagvanorov L.	20
	Implement ML model for emotion recognition locally	2020.11.10~12.13	Dagvanorov L.	20
	Test ML model for eye tracking locally	2021.01.10~01.15	Dagvanorov L.	5
	Test ML model for emotion recognition locally	2021.01.16~2021.01.20	Dagvanorov L.	5
	Deploy ML models to the server	2021.01.21~02.15	Dagvanorov L.	40
	Test ML models on the server	2021.02.17~03.05	Dagvanorov L.	10
	Help backend developer with ML models integration	2021.03.06~03.15	Dagvanorov L.	10

<b>Frontend</b>				
	Create login/register page mockup	2020.11.10~12	Kulakov A. D	2
	Create user dashboard page mockup	2020.11.13~15	Kulakov A. D	2
	Create admin dashboard page mockup	2020.11.16~18	Kulakov A. D	2
	Create user video view page mockup	2020.11.19~21	Kulakov A. D	2
	Create admin stats page mockup	2020.11.22~23	Kulakov A. D	2
	Create the login/register page	2020.11.24~28	Kulakov A. D	5
	Create the user dashboard page	2020.11.29~12.02	Kulakov A. D	5
	Create the admin dashboard page	2020.12.03~05	Kulakov A. D	5
	Create the user video view page	2020.12.06~08	Kulakov A. D	5
	Create admin stats page	2020.12.09~11	Kulakov A. D	5
	Integrate all pages together	2020.12.12~14	Kulakov A. D	5
	Integrate frontend with backend	2020.12.15~17	Kulakov A. D	5
<b>Backend</b>				
	Create REST API for user/admin	2021.01.10~13	Kulakov A. D	10
	Create a database for user info storage	2021.01.14~15	Kulakov A. D	5
	Create a database for video info storage	2021.01.16~17	Kulakov A. D	5

	Create API for video processing and displaying	2021.01.17~20	Kulakov A. D	10
	Create a server for ML models	2021.01.21~23	Kulakov A. D	5
	Integrate ML models with backend	2021.01.24~02.10	Kulakov A. D	40
	Create a database for stats	2021.02.11~15	Kulakov A. D	10
	Create an API for stats processing & collection	2021.02.15~22	Kulakov A. D	20
	Deploy final web app	2021.02.23~03.01	Kulakov A. D	20
	Perform final web app testing	2021.03.02~10	Kulakov A. D	10

Table 3. Responsibility matrix

### 5.3. Communications Management Plan

Communications	Format	Frequency	Owner	Audience
Weekly Status Update	Zoom meeting	Once a week	Project manager	Customer and Project team
Team meeting	Zoom meeting; Telegram; VK	Once in 2 weeks	Project manager	Project team

Table 4. Communication Management Plan

## 6. CONCURRENCE ANALYSIS

If we take a look at the market, there are also ‘text analysis’ (to determine author’s perception of a specific topic), ‘speech analysis’ (to analyze voice recordings or live customer calls) along with facial analysis.

According to this study, over the next five years the Emotion Analytics market will register a 63.0% CAGR in terms of revenue, the global market size will reach US\$ 1553.1 million by 2024, from US\$ 220.2 million in 2019.

Main competitors list include:

- Affectiva. Measures consumer emotional response on video ads with eye tracking and emotion detection algorithms.

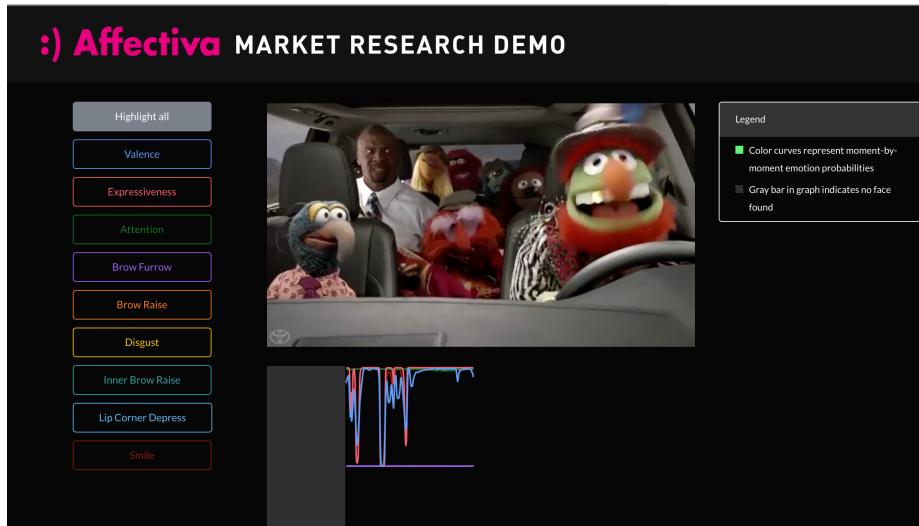


Image 2. Example existing solution. Affectiva.

- RealEyesIt. Analysis video ads with help of emotional detection algorithms

## 7. FUNCTIONAL REQUIREMENTS

### *User / admin functions*

1. Ability to authorise and register a user;
2. Ability to authorise as admin;
3. Ability to get aggregated statistics over each video via dashboard and csv file;
4. Ability to upload the new video for testing via admin dashboard;
5. Ability to delete certain videos from the system as admin;
6. Ability to watch the new video as user;
7. Ability to select the video to watch;

### Backend server

8. The python backend server should aggregate the stats per user/per video.
9. The python server would send video stats to the admin dashboard;

### Eye tracking

10. Create the new datafile on each session start
11. Ability to check if users' face is on the screen
12. Ability to calibrate user iris location
13. Ability to continuously record eye movements of the user
14. Store eye tracking stats in the corresponding data file
15. Once the recording is finished send the datafile to the database

### Emotion recognition

16. Should work simultaneously with eye tracking

17. Create the new datafile on each session start
18. Will record emotion every second if eye tracking is detecting face
19. Once the video is finished sends the emotion data file to the database

## **8. OTHER REQUIREMENTS**

### **8.1. Non-functional**

1. The system should be able to aggregate multiple participants' views in one stats file
2. The system should detect emotions/eye tracking in real time
3. The system user/admin interface should be easy to understand
4. The system should track eyes with no more than 250px error for x, y coordinates
5. The system should be able to detect emotions with at least 65% accuracy.

### **8.2. Reliability requirements**

For the stable operation of the program, a number of organizational and technical measures must be observed:

1. Provide uninterrupted power supply
2. Check equipment regularly for reliability
3. Provide stable internet connection

### **8.3. Requirements for the composition and parameters of technical means**

For the program to work successfully, basic tools are required, such as:

1. Mouse and keyboard to enter information
2. Monitor or other device for displaying information
3. Uninterrupted Internet connection to receive data from the network
4. A computer with the minimum system requirements for compiling and subsequent program actions.
5. Camera connected to the computer where the system is installed.
6. Google Chrome browser

## 9. DESCRIPTION OF THE PROJECT ARCHITECTURE AND USED TECHNOLOGIES

### 9.1. Components of the static mode

#### 9.1.1. Data diagram

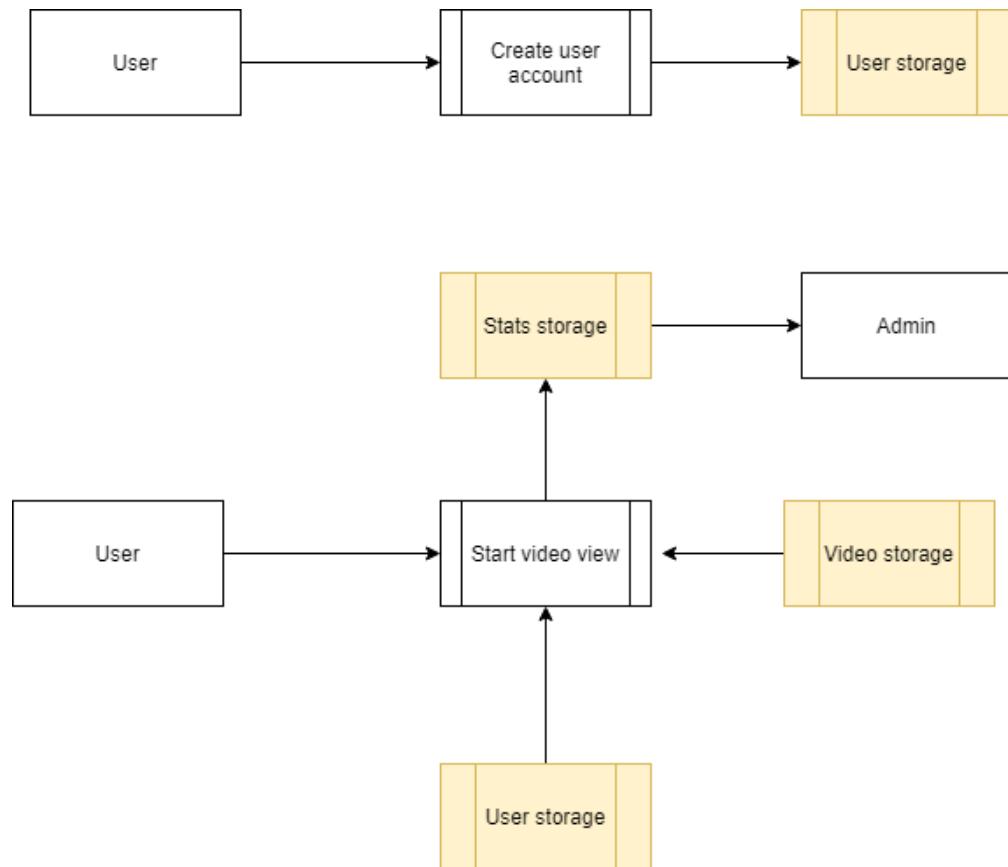


Image 3. Data diagram

Three main data storages exist in the system, including ‘user storage’, ‘stats storage’ and ‘video storage’.

When a new user is created, it will be stored in ‘user storage’

### 9.1.2. Class diagram

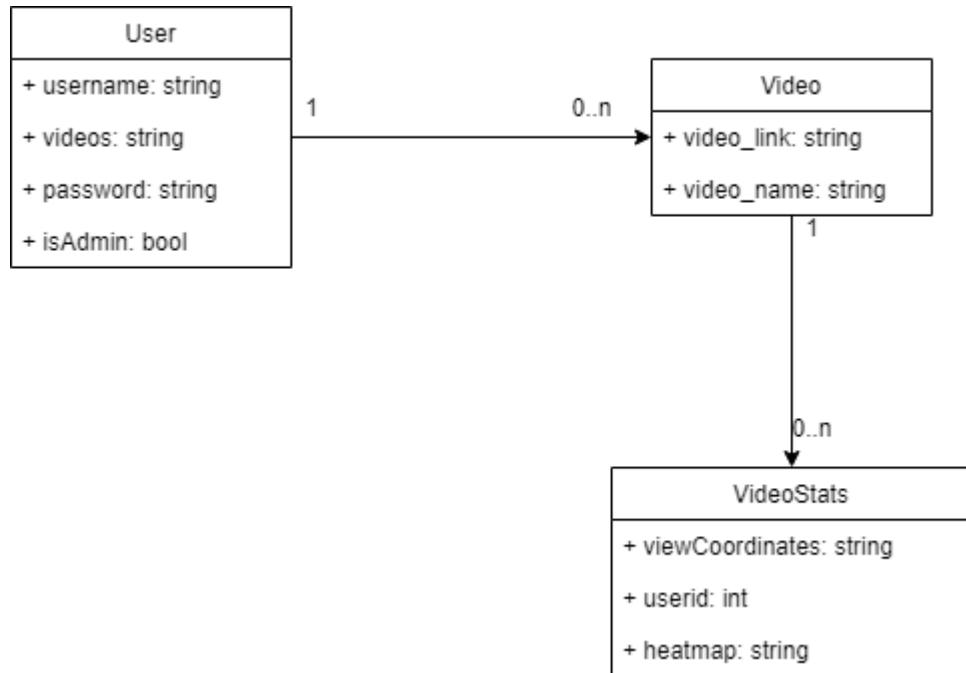


Image 4. Class diagram

A user is able to associate with multiple videos.

A video is able to associate with multiple statistics /VideoStats/ as long as multiple users are able to watch videos.

### 9.1.3. Component view

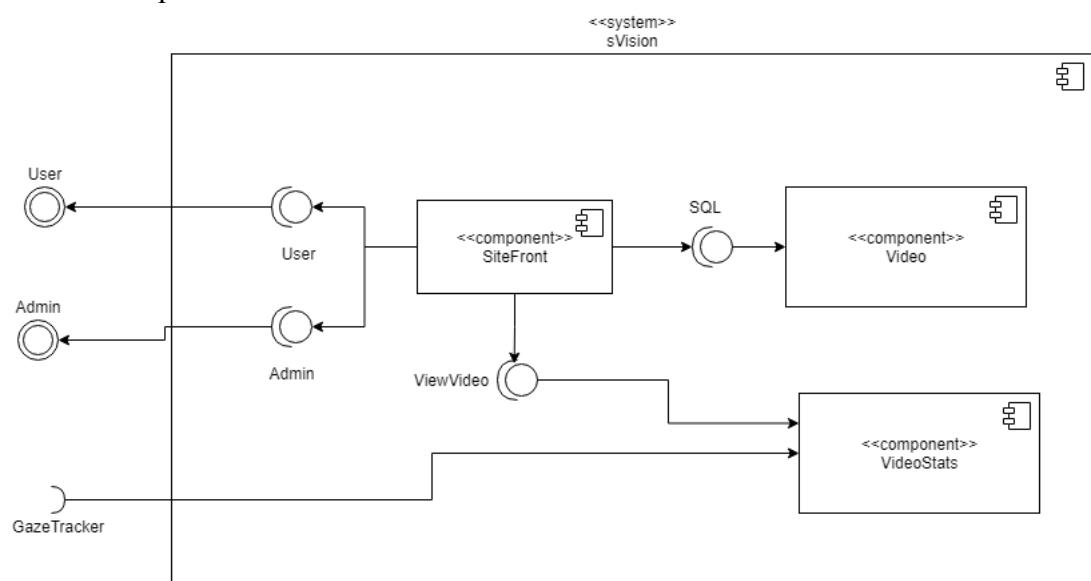


Image 5. Component view

## 9.2. Components of the dynamic models

### 9.2.1. Use case diagram

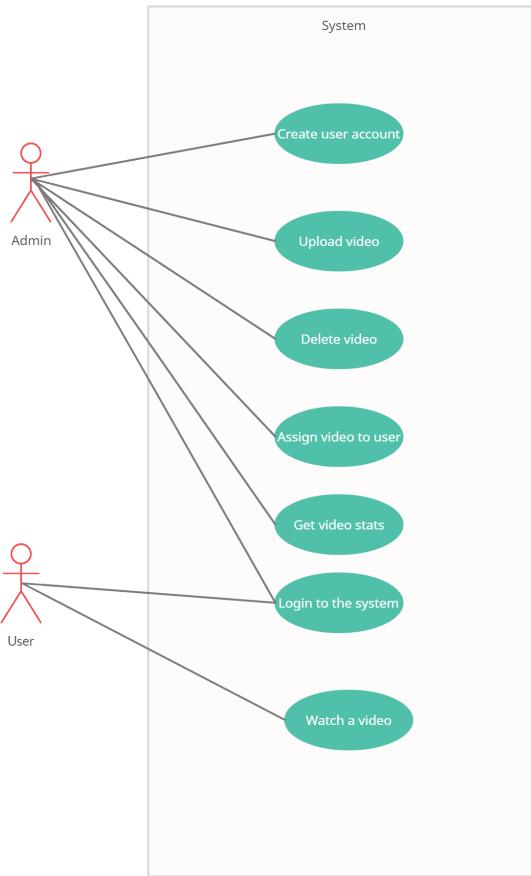


Image 6. Use case diagram

No.	Requirements	Performing actors	Use-Cases
1	<p>Only valid admin with required ‘username’ and ‘password’, is able to create a user.</p> <p>New user should have:</p> <ul style="list-style-type: none"> <li>- unique username</li> <li>- password with following specifications:</li> </ul> <p><i>Your password must contain at least 8 characters.</i></p> <p><i>Your password can't be entirely numeric.</i></p>	Admin	Create user account
2	New videos can be added only by url-link. (example: youtube-url).	Admin	Upload video

3	No specific requirements	Admin	Delete video
4	No specific requirements	Admin	Get video starts
5	No specific requirements	User	Login to the system
6	No specific requirements. Users are able to watch only the videos which are assigned to them.	User	Watch a video

Table 5. Use cases

#### 9.2.2. Data-flow diagram

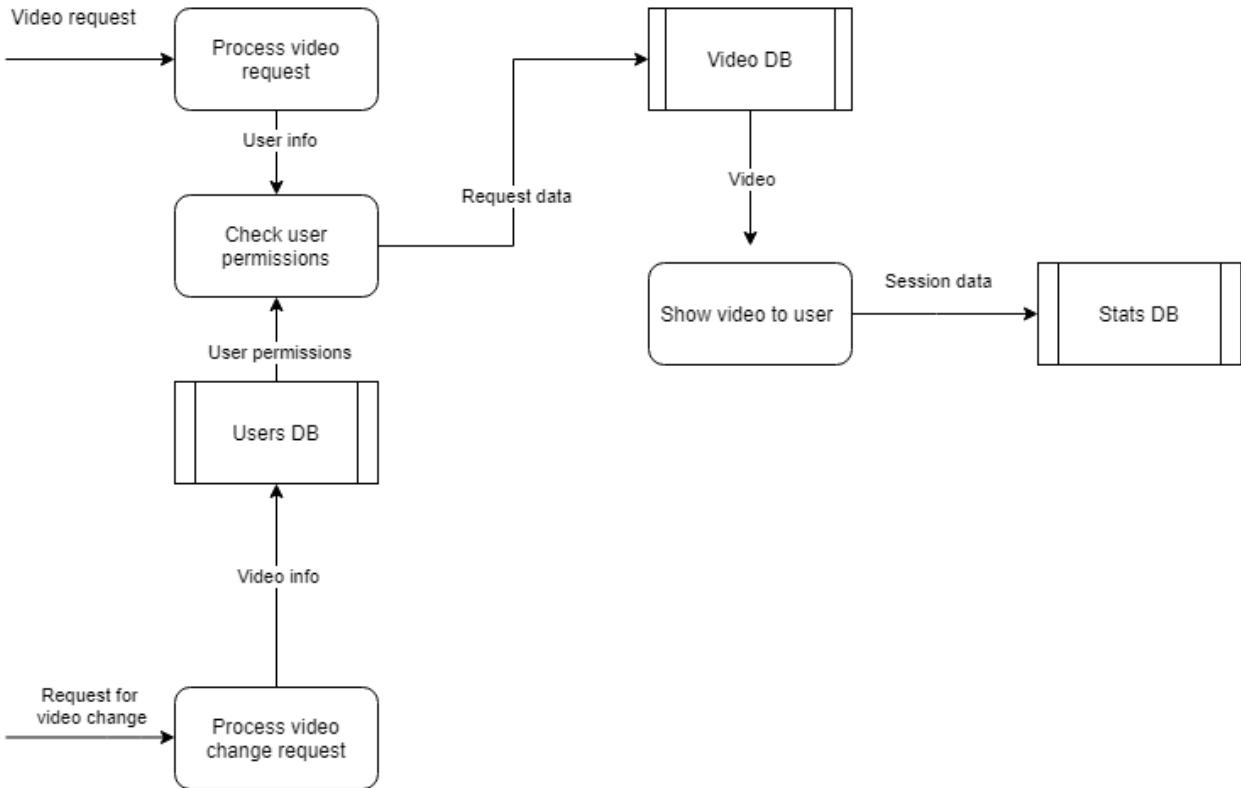


Image 7. Data-flow diagram

When a user requests a video, the system receives the request and grants access to the video based on the user's access permission.

If a user has the rights to watch the video, the system retrieves 'video information' from the 'Video DB' and shows the video to the user.

After a user watches a video, statistics of the session will be sent to the 'Stats DB'.

### 9.2.3. Activity diagram

- Video view activity

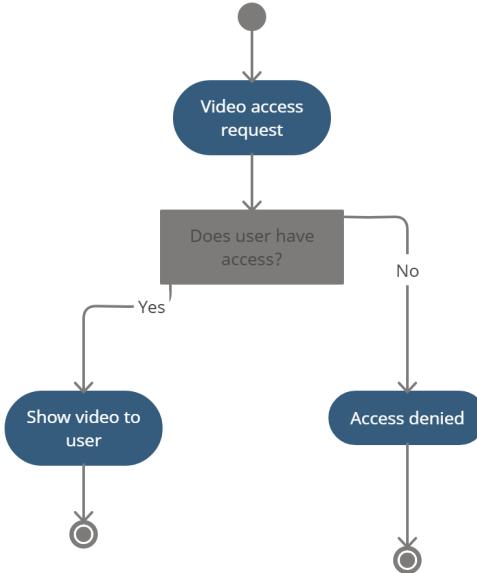


Image 8. Video view activity diagram

A user is able to watch only the videos which are accessible to him/her.

- Video upload activity

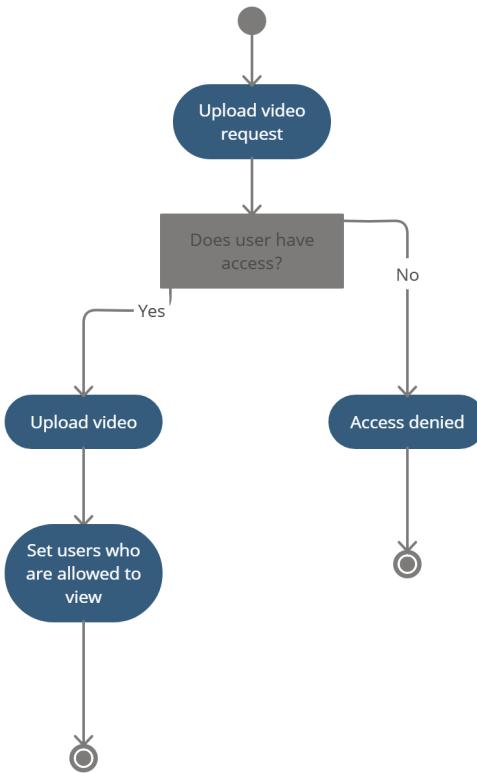


Image 9. Video upload activity diagram

Only admin and users with the rights to upload video are able to upload a video. When a user/admin successfully adds a video, they need to set users who are allowed to view the video.

- Video statistics activity

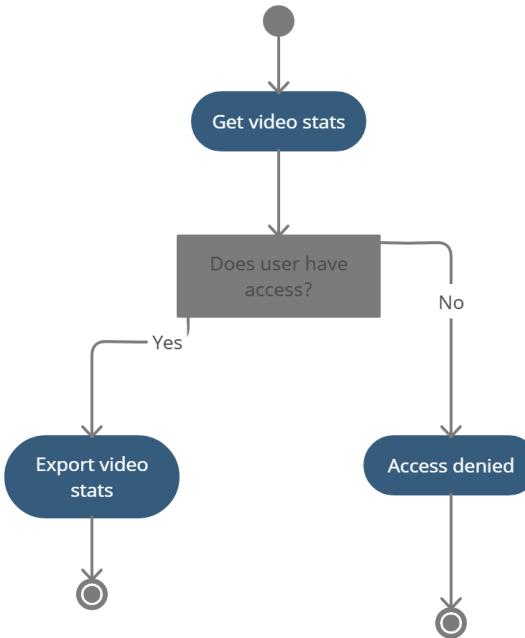


Image 10. Video statistics activity diagram.

Only admin and users with the rights to access to the video statistics, are able to retrieve sessions' statistics.

Session statistics are exported as mp4 format.

## 10. INITIAL PROTOTYPE

### 10.1. Early-stage planning prototypes

In this stage of prototyping, we followed the practice of “Incremental prototyping” since the product is made of several major units.

Phase	Name	Description
1	Eye-gaze tracking unit	Early-stage model of eye-gaze tracking model which will be applied on a web application.
2	Emotion detection unit	Early-stage model of emotion detection model which will be applied on a web application.
3	Web application	A model combines both the eye-gaze tracking and the emotion detection units along with the user management

		unit.
4	Alpha	Test the final combined web application with possible use scenarios.
5	Beta	Fixed all bugs that came in the previous stage and made sure everything works before release.

Table 6. Prototype phases



Image 11. Prototype of eye-gaze tracking model deployed on a dynamic webpage.

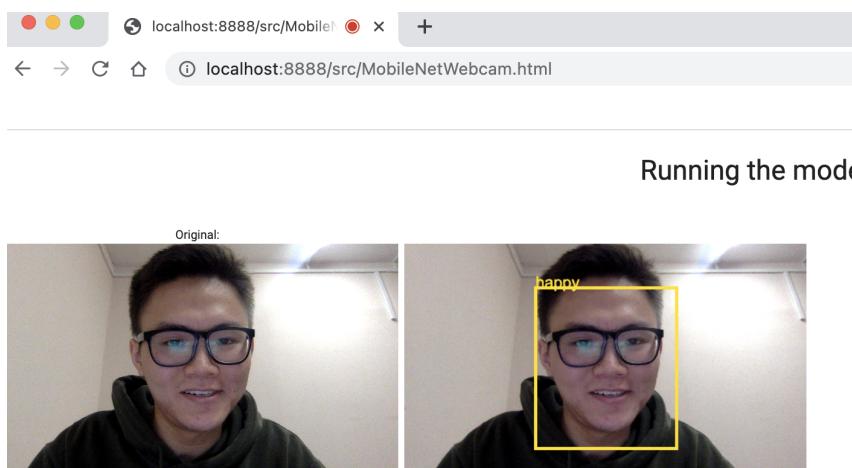


Image 12. Prototype of the emotion detection unit on a dynamic webpage.

## 10.2. First prototype

As said above the product is made of several main components. In order to achieve the result, those features need to be working clearly.

## **11. USED TECHNOLOGY**

### **11.1. Front-end and Back-end**

Django was used as the main framework for both front-end and back-end development processes. Django is a Python-based free and open-source web framework that follows the model-template-views architectural pattern. The reason to choose Django is it's light and easy to interface. Our project needed a framework which allows us to quickly deploy and test.

### **11.2. Eye-gaze tracking**

An eye-gaze tracking library, the WebGazer, uses common webcams to infer the eye-gaze locations of web visitors on a page in real time. The library is developed by Brown University. The model had the advantage of it's lightweight, accuracy and self-calibration feature. The library is written in JavaScript.

### **11.3. Emotion recognition**

face-api.js is used as the emotion recognition model of the camera. It allows us to recognize 6 emotions including, happy, sad, neutral, angry, surprised and fear. It can be deployed easily on web applications via Javascript.

## **12. MONETIZATION/COMMERCIALIZATION PROPOSALS**

Currently, in the market there are several companies offering solutions to study customers' attitude toward products. Their principal feature is to analyze data collected from users' facial expression and eye-gaze via web cameras. Also, their products are not only limited in surveying users' opinion. Several companies are offering their products to the car manufacturing companies. And there are not many open source projects focusing on this field. We assume that due to lack of sufficient data, there are not many open source projects.

## **13. FUTURE DEVELOPMENT OF THE PROJECT**

At the end of the project, we can conclude that the application has limited features due to the size of the development team and limited time. It can be recommended that, in future, the application should be extended by adding new features and deep learning models.

## **14. CUSTOMER INTERACTION REPORTS 1-6**

## **15. CUSTOMER'S COMMENT**

Comment of the team project

Team number - 20

**Students:** Artyom Kulakov, Dagvanorov Lkhagvajav

**Customer:** Hadi Saleh, PhD. Higher School of Economics

**Содержание проектной работы:** emotion recognition, eye-gaze tracking, uiux, web application

**The customer confirms the results obtained:**

№ п/п	Key project results
1.	<b>Create a web application</b>
2.	<b>Implement emotion detection feature</b>
3.	<b>Implement eye-gaze tracking feature</b>
4.	<b>Implement KPI(s) for UIUX evaluation</b>

Customer comments on the results:

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№ п/п	Критерии оценки	Оценка заказчика (от 1 до 10 баллов)
1.	Качество сбора информации и формализации требований заказчика, подготовка ТЗ	
2.	Полнота реализованного функционала, соответствие ожиданиям и требованиям заказчика, дизайн интерфейса	
3.	Результаты тестирования (тестирование на пользователях, автоматизированное тестирование)	
4.	Качество разработанной проектной документации (ТЗ и функциональные требования, архитектура, результаты тестирования, руководства пользователя, пр.)	
5.	Качество и своевременность коммуникаций, информирование об актуальном статусе, активное взаимодействие с заказчиками	
<b>ИТОГОВАЯ ОЦЕНКА ЗАКАЗЧИКА ПО ПРОЕКТУ</b>		

Индивидуальная оценка участников:

ФИО Artyom Kulakov \_\_\_\_\_ (оценка от 1 до 10)  
ФИО Dagvanorov Lkhagvajav \_\_\_\_\_ (оценка от 1 до 10)

Комментарии **заказчика** к оценкам:

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Customer \_\_\_\_\_ / \_\_\_\_\_  
signature \_\_\_\_\_ / \_\_\_\_\_

Date:

Пояснение оценок для заказчика:

5-балльная шкала	10-балльная шкала	Описание балла
отлично	10	10: в своей работе команда была инициативна, предложила решение лучше, чем сформулировал заказчик
	9	9: Работа превзошла ожидания заказчика, работы сделаны в полном объеме
	8	8: Работа выполнена хорошо, четко по ТЗ, все требования реализованы в срок и в полном объеме
хорошо	7	7: Работа в целом выполнена хорошо, остались незначительные недочеты, были некоторые сложности в работе
	6	6: В работе было множество недочетов, большинство удалось минимизировать, но некоторые остались
удовлетворительно	5	5: В работе осталось множество недочетов, которые не удалось устранить в результате работы над проектом
	4	4: Работа выполнена очень условно, результаты представлены, но не устраивают заказчика
неудовлетворительно	3	Неудовлетворительное качество работы, приёмка работы не возможно. Команда не показала требуемых результатов ни в каком объеме.
	2	
	1	
	0	

## 16. USER GUIDE

### 16.1. User: Register

The steps needed to be taken:

1. Enter the application.
2. Click the '**Register**'.
3. Write a desired username and password. Username should be unique and if the entered username is existing, the application will ask for a different username.

### 16.2. User: Watch a video and have a testing session

The steps needed to be taken:

1. Enter the application.
2. Write a registered username and it's password. Click the '**Sign in**' button.
3. The application shows the list of videos that you are allowed to watch. Click a video thumbnail.
4. Before every session, the application asks for calibration. You need to allow the browser to turn on the web camera.
  - a. Sit near the web camera and make sure your face is in the frame which is located at the left-most.
  - b. Click on each of the 9 points on the screen. You must click on each point 5 times till it goes yellow. This will calibrate your eye movements. You need to look at your mouse cursor while calibrating.
5. User is able to pause, stop and start new session by clicking the buttons, '**Resume**', '**Pause**', '**Start**'.

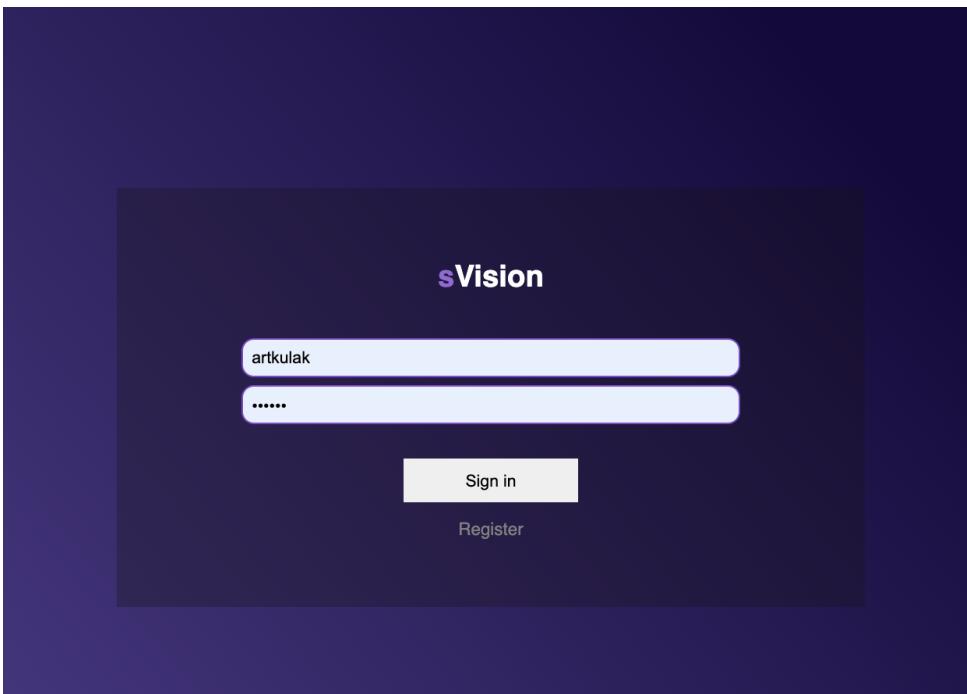


Image 13. Login page

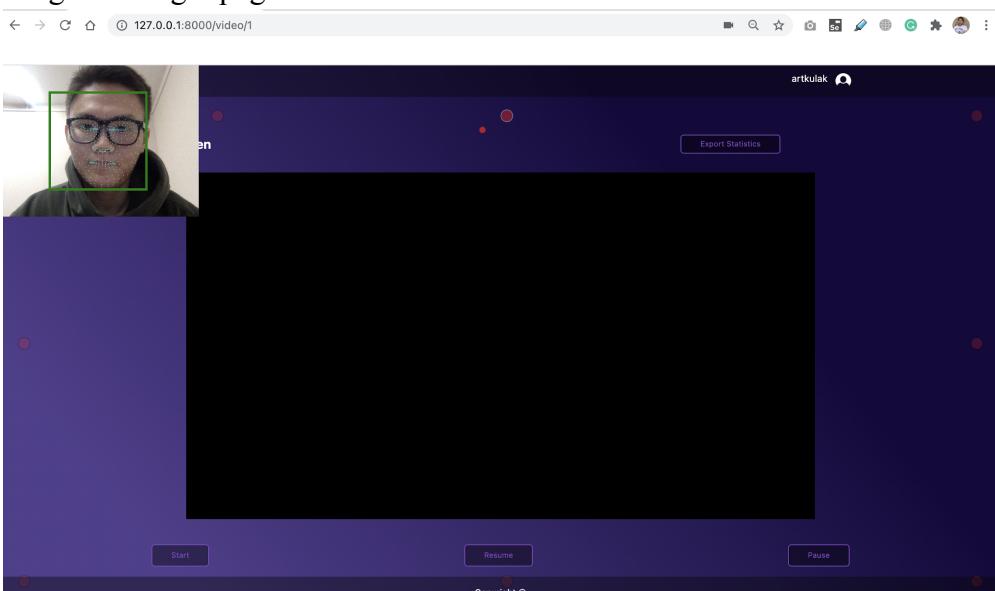


Image 14. Video view page

### 16.3. Admin: Add and remove a user

The steps needed to be taken:

1. Admin needs to log in to the application with valid username and password. Admin can enter the application with the same procedure as the user.
2. Click the '**Control Panel**' and the application will ask username and password again. You are required to write down again.
3. The application will show the dashboard of the application. You are able to modify the user information in the **Users** section. You are able to modify all information of a user including login dates, password, email address and registered date.

#### 16.4. Get statistics

After each session, the user is able to download the statistics by clicking the button ‘Export Statistics’. As a result, a video showing eye-gaze location and emotion changes over the period.

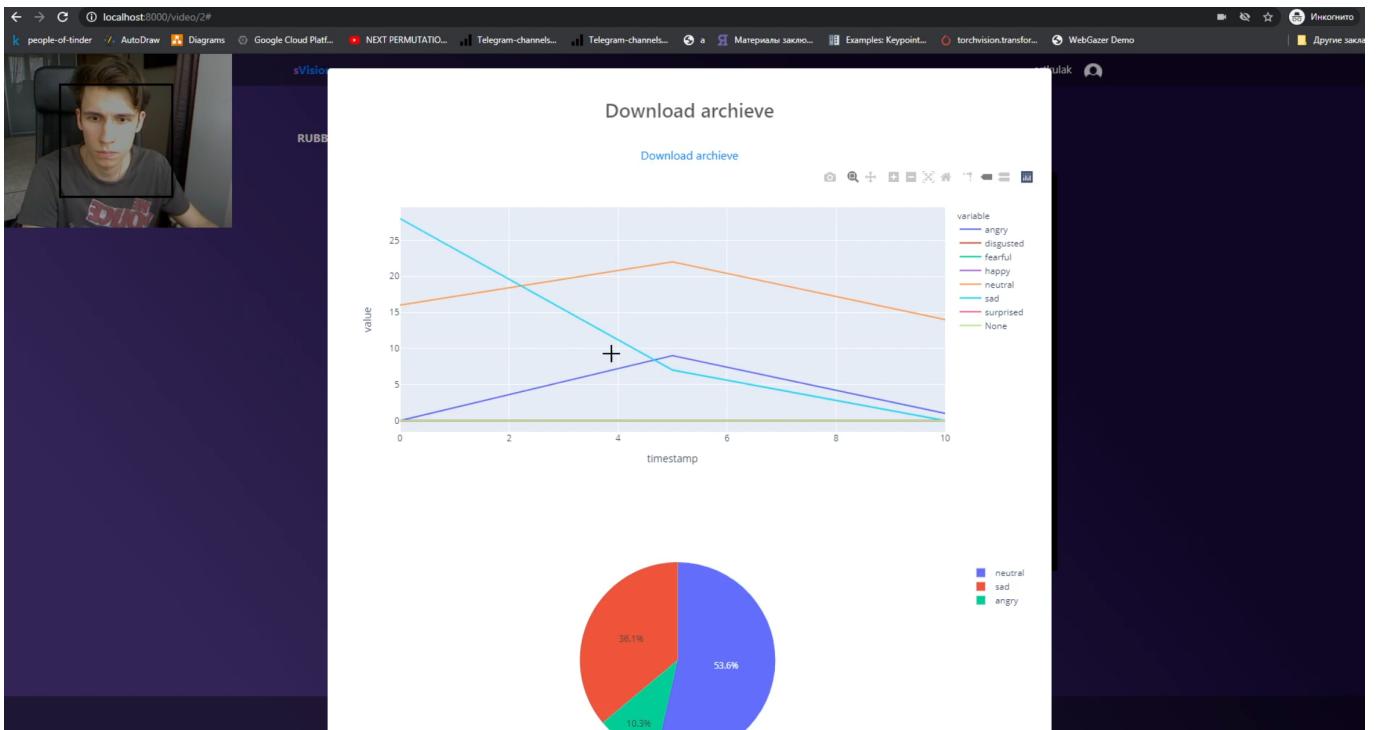


Image 15. An example emotion recognition result.

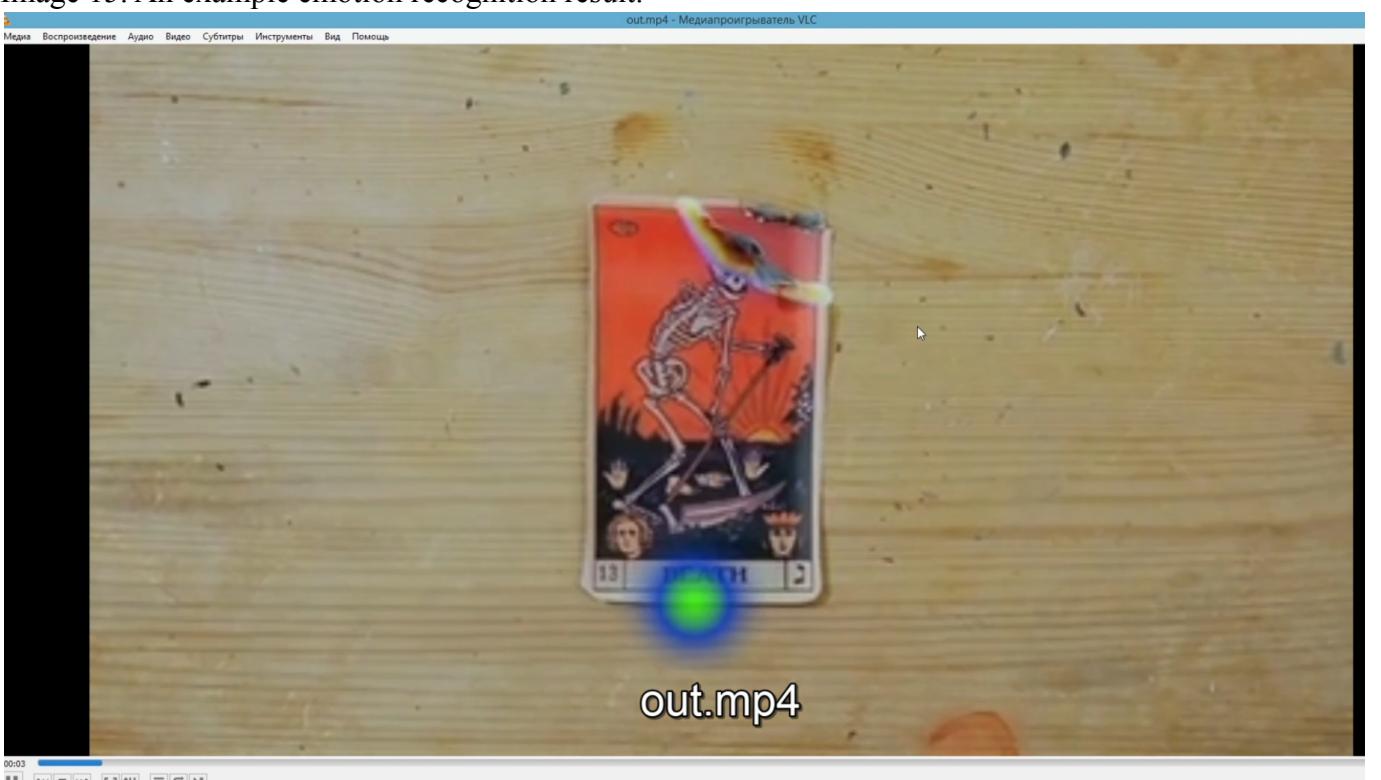


Image 17. An example video of eye-gaze tracking.

## 17. LITERATURE

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