AFEKA The Academic College of Engineering in Tel Aviv

Software Engineering

Project Name: AI-generated Voice Recognition

Engineering Report

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Submission Date:	18/02/2024

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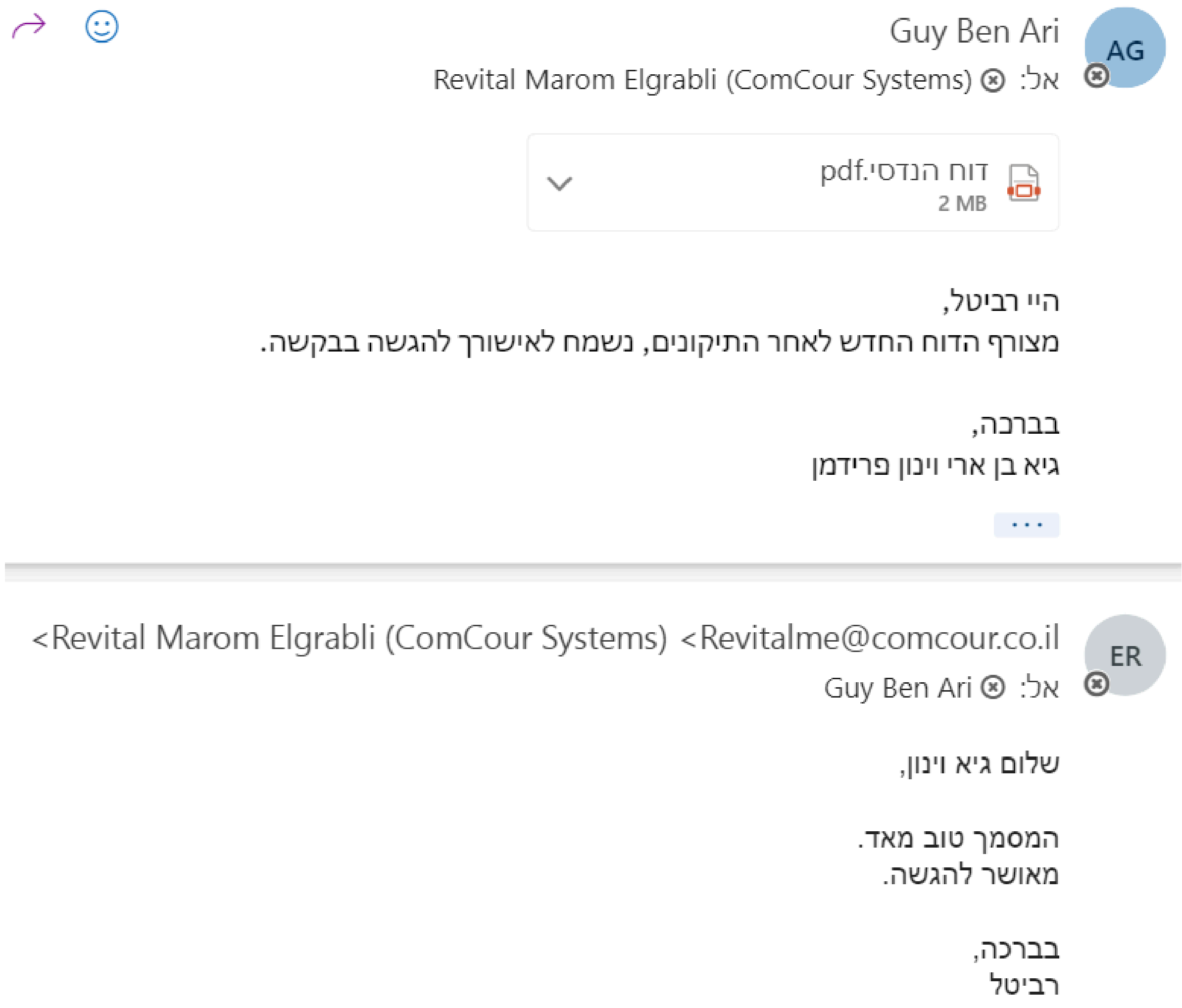
Supervisor Approval



Guy Ben Ari

אל: Revital Marom Elgrabli (ComCour Systems)

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היי רביטל,
מצורף הדוח החדש לאחר התיקונים, נשמח לאישורך להגשה בבקשה.

בברכה,
גיא בן ארי וינון פרידמן

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אל: Guy Ben Ari

שלום גיא וינון,

המסמך טוב מאד.
מאושר להגשה.

בברכה,
רביטל

Executive summary

Firstly, let's cover the project goals and requirements: The AVR (AI Voice Recognition) project is dedicated to tackling the growing threat of voice spoofing by developing a sophisticated voice authentication system. With a focus on accuracy and ease of integration, AVR aims to detect voice spoofing attempts reliably while offering seamless integration into various systems. This entails robust algorithms capable of discerning between genuine and spoofed voices, as well as an API (Application Programming Interface) structure that allows for swift integration without extensive configuration or modifications.

The success of the AVR project is measured by the strides made in enhancing the accuracy of its models and optimizing the responsiveness of its APIs. The AVR system strives to achieve 95% accuracy in predicting spoofing attempts, the sprouting industry standard. By achieving notable improvements in both areas, this report serves as a testament to the efficacy of AVR in combating voice spoofing. Not only does AVR boast higher accuracy rates in detecting spoofed voices, but its APIs also exhibit smoother interactions, ensuring minimal latency and seamless integration into diverse systems.

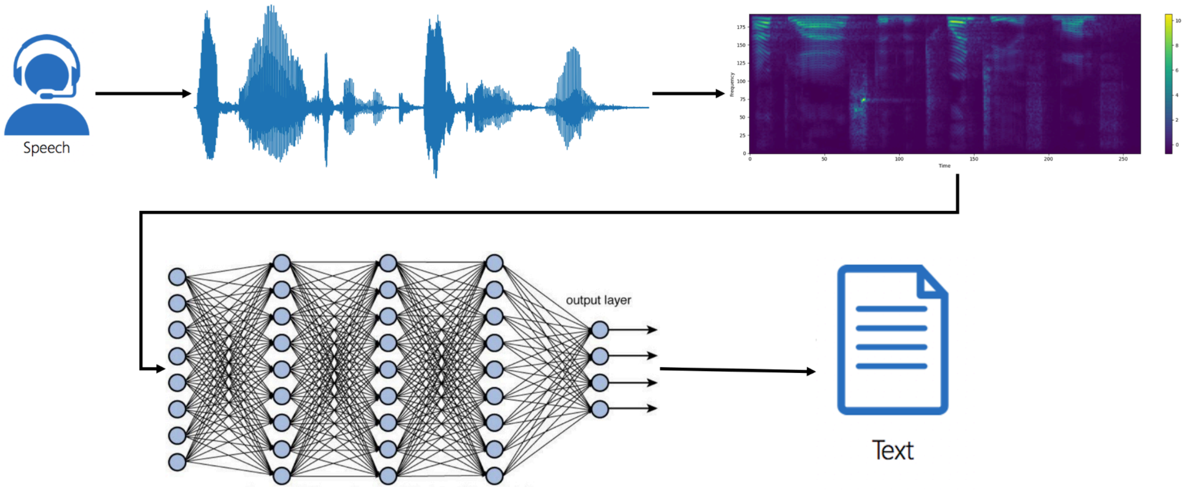
AVR's development is underpinned by a rigorous scientific methodology that combines extensive literature review with the integration of state-of-the-art technologies like CNN (Convolutional Neural Networks) and LSTM (Long Short-Term Memory) networks. Data gathering for training and validation purposes involved the collection of diverse voice samples encompassing various accents, ages, genders, and spoofing methods totalling at 220,000 data points. This meticulous approach ensures the robustness and generalizability of AVR's models, bolstering its effectiveness in real-world scenarios.

The AVR system considered numerous alternatives to ensure that progress is constantly made. Some include creating a fully custom voice sample database if our sources such as the renowned ASVspoof dataset would become unavailable, others include accounting for situations where the training pipeline for the model is hurt beyond repair and architecture of "Online learning", where the model would not be trained and instead would work with 'uncurated live data'. Other alternatives and safeguards were implemented to ensure system integrity and functionality even if required libraries were decommissioned or became unavailable.

AVR's solution leverages a sophisticated blend of mathematical and engineering principles, including CNNs, LSTMs, Neural Networks, and AI-driven techniques. Through the analysis of Mel spectrograms for voice representation and advanced image and voice analysis algorithms for feature extraction, AVR establishes a robust foundation for accurate voice authentication. This comprehensive approach enables AVR to adapt to evolving spoofing techniques and maintain high levels of accuracy and reliability.

AVR is encapsulated within a versatile black box API module designed to receive voice samples as input and deliver real-time predictions regarding voice authenticity. This modular architecture allows for seamless integration into existing systems, providing an additional layer of security without disrupting workflows. By abstracting the complexities of voice authentication into a user-friendly API interface, AVR empowers organizations to enhance their security posture with minimal effort and maximum effectiveness.

To summarize, the AVR project represents a significant advancement in the field of voice authentication, offering a robust solution to the pervasive threat of voice spoofing. By combining cutting-edge technologies with meticulous scientific methodology, AVR achieves high accuracy in detecting spoofed voices while ensuring seamless integration through its modular API design. With a solid mathematical and engineering basis and a comprehensive approach to data gathering and analysis, AVR emerges as a formidable tool in safeguarding against voice spoofing attacks, poised to bolster security measures across diverse industries with its unmatched precision and efficiency.



1. Compliance With Charter Document

1.1. In this chapter, the details and response to the needs, goals, and objectives defined in the initiation document will be presented, including the changes that have taken place since the initiation document was submitted.

1.2. These topics will be detailed in the structure of a table that will contain the concentration of the changes, their nature, and reasons for the change.

1.3. As part of the above breakdown, each change must be defined and its nature specified, clarify in which part of the project the change was made (in particular changes in requirements, functionality or products), the date of its occurrence, who initiated the change (student, supervisor or projector), who approved it and what it means for the project, with an emphasis on:

1.3.1 Changing the configuration of the solution, with an emphasis on changes in content, goals, targets, indicators

1.3.2 Increasing/reducing the scope of the system, changes in the presented block architecture, changes in alternative contents and modules

1.3.3 Special problems hindering the progress of the project must be specified (such as lack of data, lack of means of execution, realization of risks, non-cooperation on the part of a client in an industrial project, etc.).

Table 1.1 - The compliance to the Project Charter Document

Change number	Charter document	Reason for change	Part affected	Date	Participants	Implications
1	section 2	ASV2019 was used, but not exclusively	Model training, DB	09.23	Students	Diversification of datasets enhances model robustness
2	section 5	local storage was used	DB	08.23	Students	Potential impact on scalability and data management;cost-effective but requires careful data strategies.

3	section 4	Move to Jupyterlab	Development environment	07.23	Students	Enhancements in interactivity and collaboration; familiarity required from the team.
4	section 5	no academic gaps	Model architecture	01.24	Students	potential acceleration in development.
5	section 1	a website and download link	Project accessibility	2024	Students	Ensures broader accessibility for users; commitment to user-friendly outcomes

2. Methodology of tools

2.1. The engineering tools and methods that were actually chosen for the characterization and design/implementation of the system developed as part of the project will be detailed, with an emphasis on the engineering tools and methods for formulating design specifications in order to achieve the goals and objectives of the project and the system, including:

2.1.1. The project team will present and detail the selected tools, explanations of the reason for choosing a tool/method and the contribution of a tool/method to the planning and implementation of the system and the success of the project.

Table 2.1 - Selected tools

Tool	Explanation
Using Jupyter lab	A development environment that is convenient for running several Python notebooks, the information can be transferred easily with the help of the hard disk. All running parameters and resources can be controlled.
Libraries such as LIBROSA, SOUNDFILE	Using these libraries contributes to the understanding of the sound files, in that they provide tools that help to decode the sound waves from the audio, and also allow to extract pitches and thus help to process the sound in a better way. With their help we create the Mel-Spectrogram, which is considered a professional standard in the field.
LSTM type architecture	This type of architecture is the most recommended architecture for use in models related to voice processing, following many articles read on the subject
Using Convoluted neural networks	Using CNN is essential in detecting voice forgeries and excels in capturing nuances of small features, especially by using MFCC and spectrograms. By leveraging the complex layers, neural networks learn complex patterns automatically, which helps them find anomalies in fake voice.
Use of a data set that includes a detailed metadata table	There is a good division between the training and the validation, in addition the information can be accessed efficiently and quickly by the address

	links listed in the table, thus shortening the access and search time, which contributes to shortening the running time of the model
Combining voice processing models with image processing models.	Developing a more reliable and high-quality model with the help of combining the pitches in the sound segments as well as removing the pitches from the image

2.1.2. Details of tools and products for design, presentation and analysis, such as entity relationship diagrams (ERD), flow charts, use cases, sequence diagrams, implementation alternatives, architecture diagrams. Attach the charts again and explain the tools.

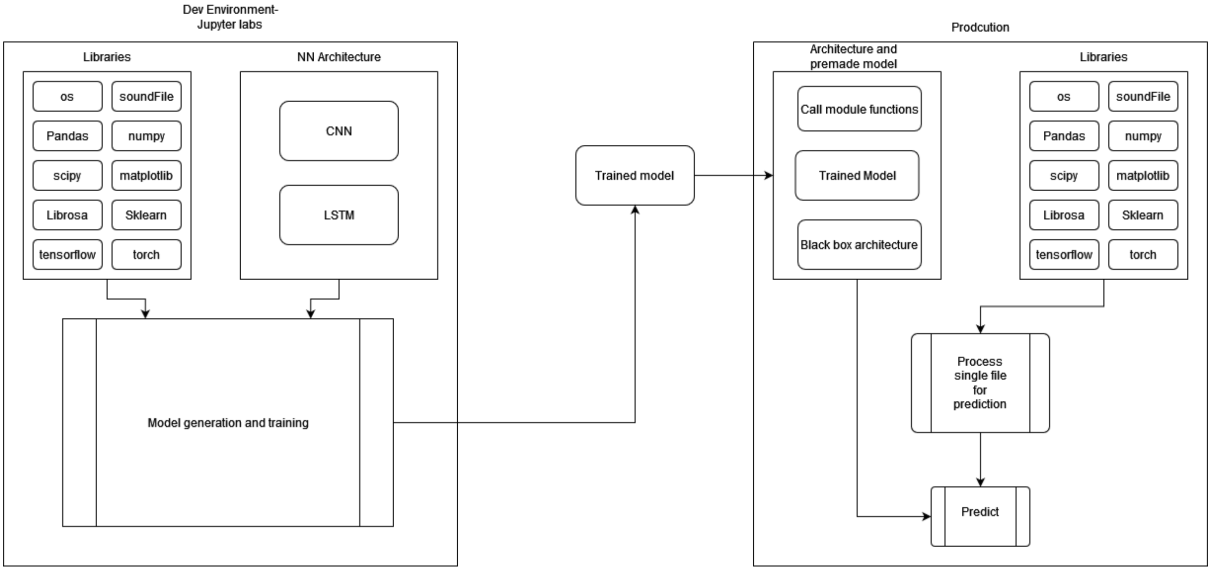


Diagram 2.1 - System tools Architecture diagram

Tools Use Case 1: Load and prepare Database. (See Diagram 2.2)

Primary flow:

1.Dev starts training pipeline
2.Begin DB loading by listing path to metadata table
3. calls pandas.read_excel with the path to receive dataframe in return
4.call train_test_split() on the dataframe to receive train and temp dataframes
5. call train_test_split() again on temp to receive valid and test dataframes
6. continue to model creation and training.

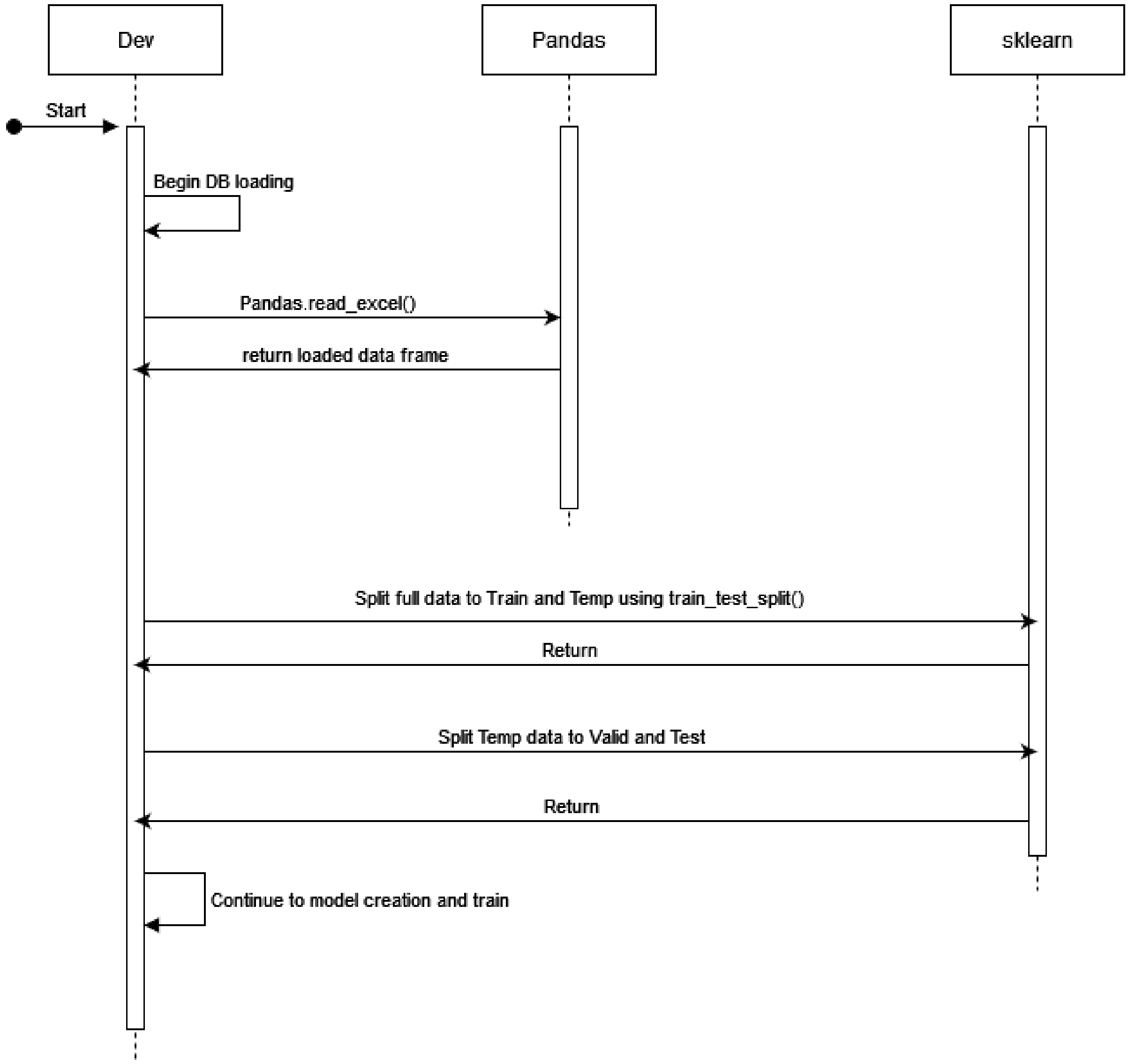

Dev
Pandas
sklearn
Start
Begin DB loading
Pandas.read_excel()
return loaded data frame
Split full data to Train and Temp using train_test_split()
Return
Split Temp data to Valid and Test
Return
Continue to model creation and train

Diagram 2.2 - Tools Use Case 1

Tools Use Case 2: Prepare audio sample for prediction model. (See Diagram 2.3)

Primary flow:

1. Module is called in larger system to predict on an audio sample
2. begin feature extraction
3. pass the audio sample to librosa via librosa.feature.melspectrogram() to obtain mel spectrogram image
4. pass the image again to librosa via librosa.power_to_db() to scale the mel spectrogram by decibels
5. add the image data to features of audio sample
6. pass features to the prediction model.

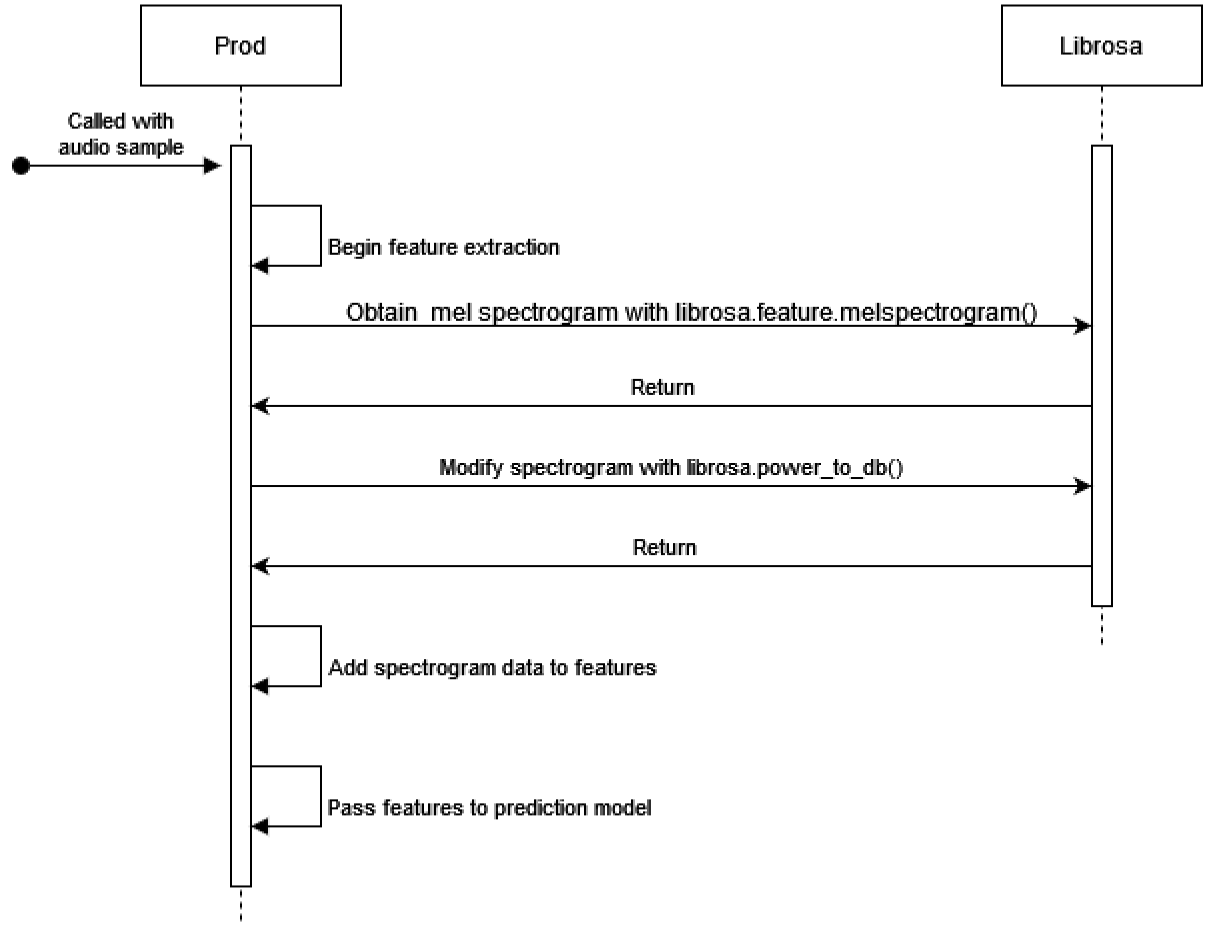
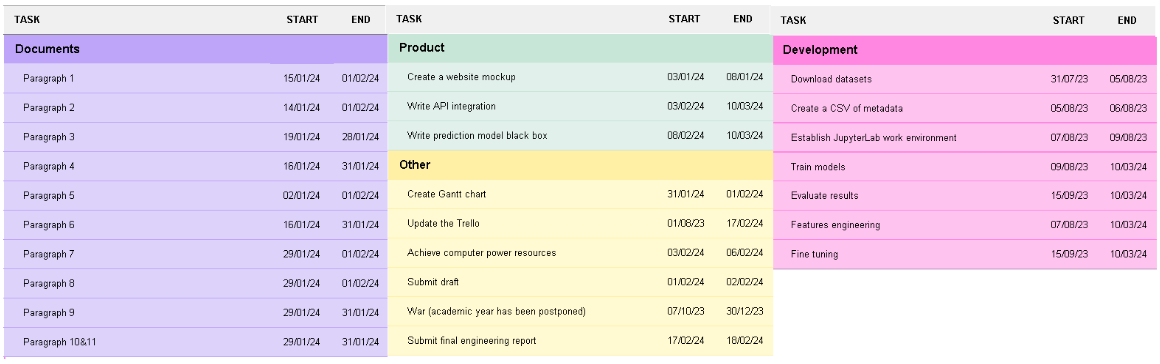

Prod
Librosa
Called with audio sample
Begin feature extraction
Obtain mel spectrogram with librosa.feature.melspectrogram()
Return
Modify spectrogram with librosa.power_to_db()
Return
Add spectrogram data to features
Pass features to prediction model

Diagram 2.3 - Tools Use Case 2

2.2. The team will present and detail an updated schedule for the project (Gantt chart/work plan charts and schedules, including updates, if there were any, in the areas of task distribution and updated areas of responsibility among the members of the project team.

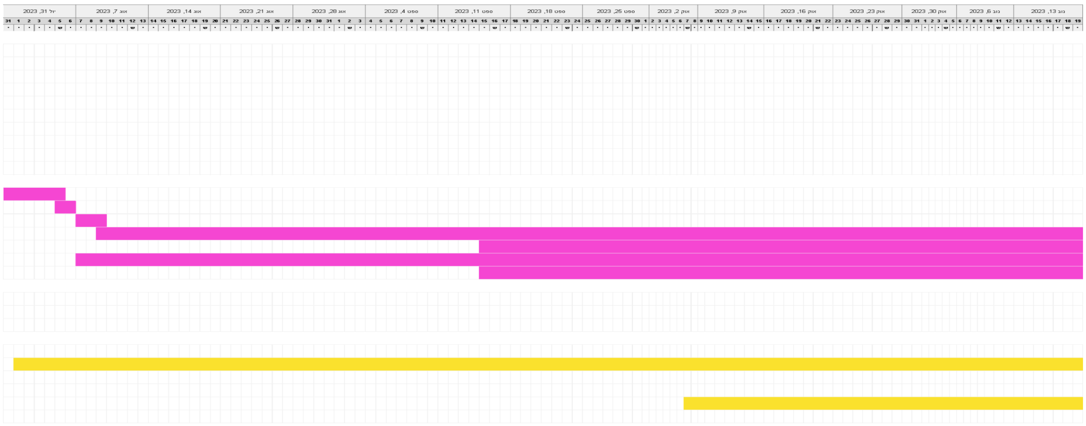


TASK	START	END
Documents		
Paragraph 1	15/01/24	01/02/24
Paragraph 2	14/01/24	01/02/24
Paragraph 3	19/01/24	28/01/24
Paragraph 4	16/01/24	31/01/24
Paragraph 5	02/01/24	01/02/24
Paragraph 6	16/01/24	31/01/24
Paragraph 7	29/01/24	01/02/24
Paragraph 8	29/01/24	01/02/24
Paragraph 9	29/01/24	31/01/24
Paragraph 10&11	29/01/24	31/01/24

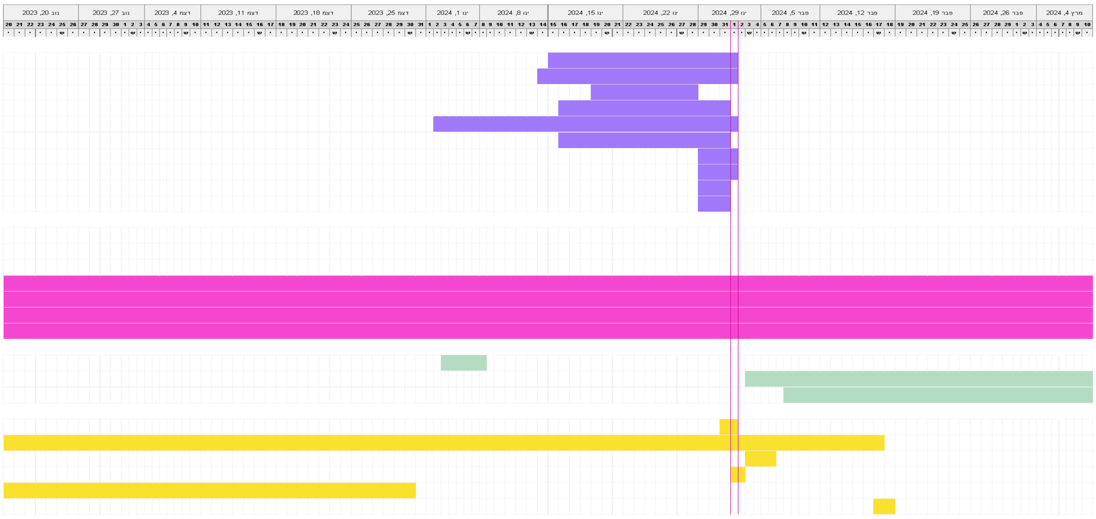
TASK	START	END
Product		
Create a website mockup	03/01/24	08/01/24
Write API integration	03/02/24	10/03/24
Write prediction model black box	08/02/24	10/03/24
Other		
Create Gantt chart	31/01/24	01/02/24
Update the Trello	01/08/23	17/02/24
Achieve computer power resources	03/02/24	06/02/24
Submit draft	01/02/24	02/02/24
War (academic year has been postponed)	07/10/23	30/12/23
Submit final engineering report	17/02/24	18/02/24

TASK	START	END
Development		
Download datasets	31/07/23	05/08/23
Create a CSV of metadata	05/08/23	06/08/23
Establish JupyterLab work environment	07/08/23	09/08/23
Train models	09/08/23	10/03/24
Evaluate results	15/09/23	10/03/24
Features engineering	07/08/23	10/03/24
Fine tuning	15/09/23	10/03/24

Screenshot 2.4 - Gantt chart tasks



Screenshot 2.5 - Gantt chart 31.07.23-19.11.23



Screenshot 2.6 - Gantt chart 20.11.23-04.03.24

2.3. The team will present and detail an updated analysis and risk management: presentation of main risks and the ways of dealing with them (in technical and administrative aspects only), including a table of the main specific risks, their degree of severity and the ways of dealing with them.

Table 2.5 - Tools risks and mitigations

Tools	Major risks	Probability	Severity	Ways of mitigation	Damage intensity	Previous damage intensity	Change in the risk
1. Using Jupyter lab	Dependency on Software Versions and Compatibility	2	3	1. Regularly update Jupyter Lab and its dependencies 2. Maintain a version control system for the project to track changes and dependencies.	6	6	Low
2. Using libraries	Compatibility Issues: Risks associated with compatibility across different operating systems and environments. Loss of Support: Risk of libraries updating, and no longer supporting required features in our system.	2	4	1. Regular Updates: Keep libraries up to date to address compatibility issues. 2. Optimization: Implement optimization strategies for performance improvement. 3. Write the code such that the library of choice isn’t essential, an can be altered without affecting the whole system	8	10	Moderate

3. Use of LSTM	Overfitting: Risks associated with the LSTM model learning noise in the training data, leading to poor generalization. Complexity: Risks due to the complexity of LSTM models, potentially resulting in longer training times and increased resource requirements.	4	3	1. Regularization Techniques: Implement dropout and other regularization techniques to mitigate overfitting. 2. Complexity Analysis: Carefully analyze the trade-offs between model complexity and performance.	12	6	Moderate
4. Use of CNN and deep learning	Computational Resources: Training deep networks might require significant computational power. Explainability: CNN can sometimes fall outside the realm of Explainable AI, as behavior in the hidden layers can't always be explained. Leaving mistakes without a clear way to correct them	3	4	1. Acquire computing resources from Afeka College. 2. Explore techniques like layer-wise relevance propagation (LRP). Additionally, employ model-agnostic interpretability methods. 3. Acceptance of the nature of CNN as not deterministically explainable, and use its advantages to achieve high accuracy.	12	NaN	High (this is a new risk)

5. Combining different models	Integration Complexity: Challenges in merging different modalities of data. Model Performance: Mismatch between sound and image models affecting overall performance.	4	4	1. Carefully design an integrated architecture, considering the strengths and limitations of each model. Implement thorough testing and validation during the integration process. 2. Create multiple different combinations of different models, thus having ample choice for the best combination.	16	12	Moderate

2.4 In the framework of the above, the team will present and detail the update of the treatment status of the restrictions:

2.4.1 Engineering knowledge that was completed and required study and deepening.

An advanced academic course on neural networks and deep learning was taken, in addition a course on language and speech was taken in order to gain comprehensive knowledge that can help understand problems or aspects of the project's goal.

3. Results & High Level Design

3.1. The team will present and detail the contents of the selected alternative when, as an integral part of presenting and detailing the chosen alternative/configuration, the team will detail the engineering considerations for the selection, against the goals and objectives of the system that will be implemented within the project.

Table 3.1 - Selected alternatives

Component	Alternative	Advantage	Disadvantage	System Goals
Database of voice samples	Create a DB by ourselves	- Database is tailor made to our problem and algorithm - No need to worry about losing access at a later point - Certainty in lack of issues	- Creating a database takes a lot of time and effort - We risk having a low sample size, or low variance as our sources are limited - We will need to acquire high quality recording equipment as well as storage space	- Data Integrity - Data Availability - Scalability - Reliability - Cost Efficiency
Pre processing - feature preparation and selection	Usage of deep-learning algorithms that don't require feature Preparation	- Saves time, no need to analyze features and choose which ones to extract. - These types of algorithms can usually detect patterns other models and algorithms cannot	- Deep learning isn't an explainable AI, making mistakes not be able to be traced to their source. - Requires significantly more computing resources, making training or even just running the model heavy and expensive	- Extract features to improve efficiency of learning algorithm - Provide meta information on correlation between features and categories, allowing intelligent redesign of the algorithm

Training - AI algorithm	Choosing a architecture that doesn’t need training, a “learn as you run” one	- Saves time as no training is needed - no need to secure a database	- Bad initial results for a while until model picks up speed - no way to verify correctness of predictions reliably, which could lead to a spiral in the wrong direction	- Model Accuracy - Performance Optimization - Model Complexity - Time Efficiency

3.2 After presenting and detailing the chosen alternative, the team will present and detail

3.2.1 System infrastructures: (for example: Internet infrastructures, infrastructures based on physical communication, secure identification systems, "cloud" infrastructures).

- The training set (DEV): The training set has only a local infrastructure that connects to the externally stored database. Its only function is to produce an accurate prediction model.
- The model and the shell (PROD): The model infrastructures are operating systems that will support the latest libraries in the model as well as data upload services for the model itself.

3.2.2 Within this framework, the team will detail the main modules, the demarcation of the system, the system services: online services, real time services, access via Android, access via laptop, etc.

- The training setup (DEV): In this setup, there are no system services beyond its central role as a trainer for a model, which will be removed later and will be wrapped in a code shell and become the PROD system. Access is through opening and running the relevant Python notebook.
- The model and the envelope (PROD): In the model there is a real-time service in that the system will return a prediction of the sound file within a few seconds. Access to the model is through downloading the shell and implementing the system.

3.2.3 In addition and as part of the above, types of information in the system will be displayed and detailed:

- The training set (DEV): The types of information are voice recordings from different databases, and the creation of spectrograms in order to process the information in them.
- The model and the envelope (PROD): The types of information are sound files that will be uploaded to the system and processed by it.

3.3 High Level Design, system architecture:

3.3.1 As a result of selecting and presenting the configuration and contents of the technological alternative chosen for implementation, the team will present and detail the planning of the system architecture as a direct product of the components and modules of the chosen alternative.

3.3.2 The required detail of the system architecture (at the initial engineering design level):

3.3.2.1 Architecture diagram of the proposed system at the level of blocks, interfaces, demarcation, services, configuration, examples:

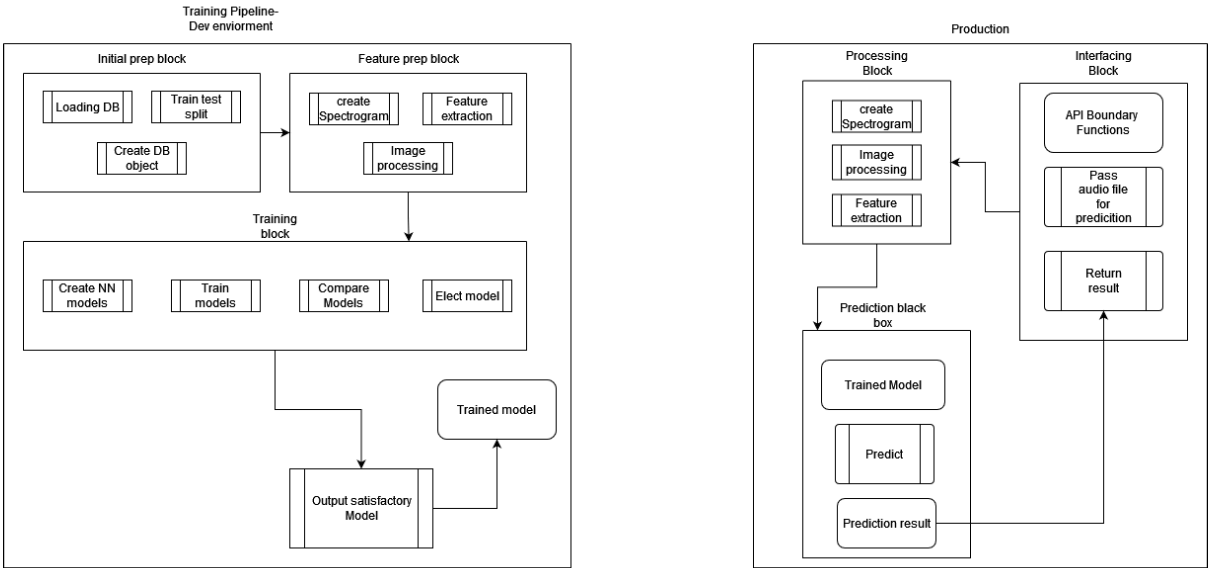


Diagram 3.2 - System Architecture diagram

3.3.2.2 Within the framework of the presentation and detail (charts and explanatory tables) each block or module in the chart must be referred to and explained how it fits into the level of system function and the level of contribution to the implementation of the system (the overall architecture).

- First it is essential to understand our system, due to its nature as a ML prediction model, is divided into two parts: The Training pipeline(see table 3.3), which is run to create a prediction model for the first time, or to improve performance as technology advances. And Production (see table 3.4), a module that is wrapped around the prediction model and provides voice-spoofing-detection services to other systems.

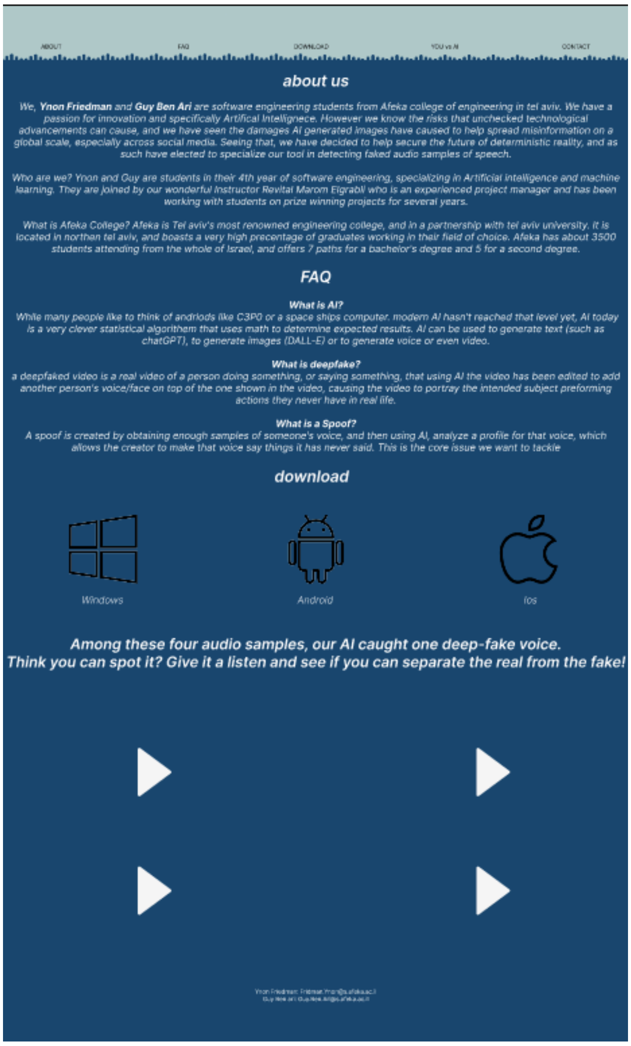
Table 3.3 - Training pipeline

<u>Development- Training pipeline</u>		
Block	**Block Explanation**	**Further Elaboration**
Initial Prep	This block is the first within our development pipeline, it is responsible for the crucial task of accessing our data in an organized fashion by creating training, validation and test splits, and creating a database object which will allow easy access to the audio samples	● The Database, stored on a local harddisk, and comprised of ~220,000 datapoints ● It utilizes a Metadata table that contains the path to their location on the harddisk, and their real/spoof label
Feature Prep	This block is responsible for extracting features from the raw audio samples, as their sample rate, or the data of the corresponding mel spectrogram. These features are essential for the models to be trained properly.	● Features are extracted by custom made functions, and are then added to the database object.
Training	The most important block in both our development and production environments, this block is responsible for creating and training our ML models, it is additionally responsible for various comparisons between the models and attempts to combine them to create better performances. Lastly it is responsible for choosing a model with a satisfactory accuracy level and outputting it.	● Training is a complicated topic, as it includes attempting various feature selections as well as varying numbers of Epocs. ● Comparisons between models are done using both their accuracy, and other metrics like their F1 score or their FP /FN ratios.

Table 3.4 - Prediction module

Production- prediction module		
Block	**Block Explanation**	**Further Elaboration**
Interfacing	This block is responsible for communicating with the system in which the module is implemented, it maintains the boundary between the two and is responsible to pass the audio samples that require prediction on into the module, as well as return the prediction result.	● The interfacing block functions are the only one available to the larger software our module is implemented in. ● The functions receive a single file of a person speaking, and return a result which indicates if the voice is fake or real
Processing	This block is responsible to extract the features from the provided audio sample to allow the prediction model to work ideally. It works similarly as the feature extraction in the development pipeline does.	
Prediction	This block works as a black box, protecting the trained prediction model the development pipeline created within it. It receives an input of features of an audio sample, and after running them through the trained model, returns a prediction on the authenticity of the sample to the Interface block.	

3.3.2.3 The team will also refer to the details of the algorithms: languages, planned implementation, integration in modules, design relationships and structure architecture and entity relationship diagram (ERD), interfaces and connectivity, GUI, UI and UX, usage scenarios of the system.



about us

We, **Ynon Friedman** and **Guy Ben Ari** are software engineering students from Afeka college of engineering in tel aviv. We have a passion for innovation and specifically Artifical Intellignece. However we know the risks that unchecked technological advancements can cause, and we have seen the damages AI generated images have caused to help spread misinformation on a global scale, especially across social media. Seeing that, we have decided to help secure the future of deterministic reality, and as such have elected to specialize our tool in detecting faked audio samples of speech.

Who are we? Ynon and Guy are students in their 4th year of software engineering, specializing in Artificial intelligence and machine learning. They are joined by our wonderful Instructor Revital Marom Elgrabli who is an experienced project manager and has been working with students on prize winning projects for several years.

What is Afeka College? Afeka is Tel aviv's most renowned engineering college, and in a partnership with tel aviv university. It is located in northen tel aviv, and boasts a very high precentage of graduates working in their field of choice. Afeka has about 3500 students attending from the whole of Israel, and offers 7 paths for a bachelor's degree and 5 for a second degree.

FAQ

What is AI?
While many people like to think of andriods like C3P0 or a space ships computer. modern AI hasn't reached that level yet, AI today is a very clever statistical algorithem that uses math to determine expected results. AI can be used to generate text (such as chatGPT), to generate images (DALL-E) or to generate voice or even video.

What is deepfake?
a deepfaked video is a real video of a person doing something, or saying something, that using AI the video has been edited to add another person's voice/face on top of the one shown in the video, causing the video to portray the intended subject preforming actions they never have in real life.

What is a Spoof?
A spoof is created by obtaining enough samples of someone's voice, and then using AI, analyze a profile for that voice, which allows the creator to make that voice say things it has never said. This is the core issue we want to tackle

download

Among these four audio samples, our AI caught one deep-fake voice.
Think you can spot it? Give it a listen and see if you can separate the real from the fake!

Ynon Friedman: Fridman.Ynon@s.afeka.ac.il
Guy Ben ari: Guy.Ben.Ari@s.afeka.ac.il

Screenshot 3.5 - Website mockup

4. Updating the testing plan

4.1. In this section, details and an update of the testing plan for the planned system, including the planned Alpha module, will be presented in a table.

4.2. The testing plan will include tests of the modules and software services, the algorithms, interfaces between the modules, the integrity of the processes, the desired results of updates, queries and system processes.

4.3 As part of the testing plan, the team will list in a table:

4.3.1 The scripts and processes to be tested.

4.3.2 The functions and scenarios to be tested.

4.3.3 For each function or scenario: what will be considered normal and what will be considered in need of repair.

Table 4.1 - Testing plan

index	Section	Content
1	Introduction	Overview: The project aims to develop an AI system capable of differentiating between genuine and deep fake sound files. Objective: Create a robust ML model for detecting authenticity in sound files, suitable for distribution outside our system.
2	Scope of Testing	Focus: Test the model's ability to distinguish between genuine and manipulated voices. Objective: Achieve high accuracy ($\alpha \leq 0.05$) in predictions and successfully export and execute the model outside our system.
3	Testing Objectives	Assess the model's performance in differentiating between genuine and manipulated sound files. Test the AI's ability to analyze and detect authenticity in newly uploaded sound files. Verify successful integration of the exported model with outside systems as a spoofing safeguard.

4	Testing Methodologies	For Training System: Refine the training process for efficiency and compare different models and inspect neuron behaviors within the revealed layers. For Final Module: Test input/output behavior for various file types and edge cases. Verify integration with other systems. For Modules and Software Services: Employ tests for modules, algorithms, interfaces, process integrity, updates, queries, and system processes.
5	Risk Assessment	Risks: Model accuracy, data quality, and scalability challenges. Mitigation: Use cutting-edge spoofing methods to create more data points, address challenges during testing and refinement.
6	Additional Testing	Test scripts and processes for reliability and accuracy. Test functions and scenarios to ensure proper execution and desired outcomes. Define normal and repair criteria for each function or scenario to guide testing.

5. Updating the details of the work plan

5.1. The updated work plan will include the updated schedules for all the engineering and administrative tasks in the project.

Sprint 1: 05.01.24 - 02.02.24

- Begin writing Engineering report
- Create a website mockup
- Continue on improving the models
- Compare first models results
- Define the architecture and tools
- Attempt to combine models for increased accuracy

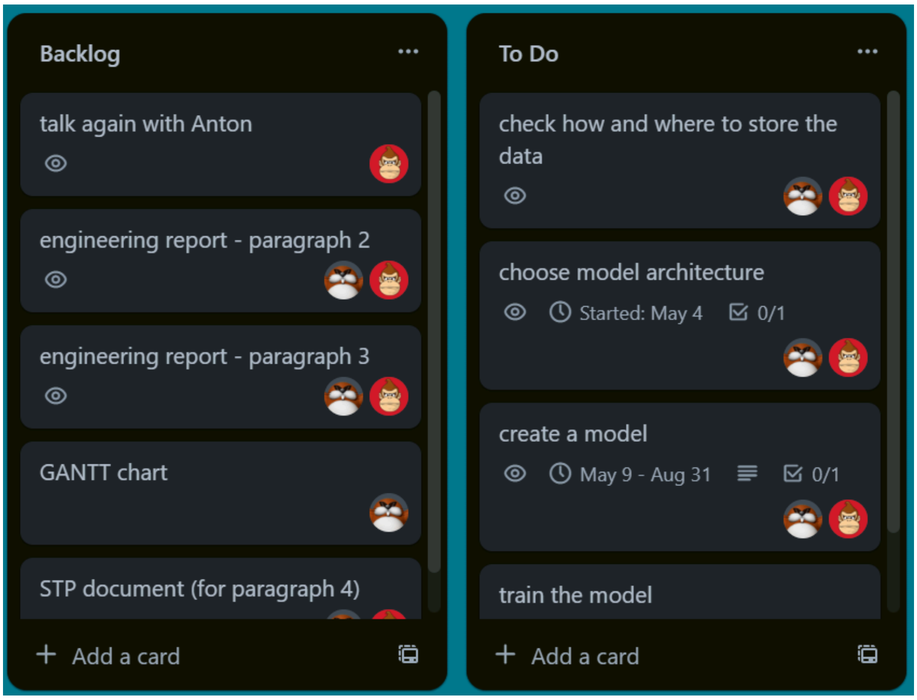
Sprint 2: 02.02.24 - 01.03.24

- Close gaps and unfinished parts from Sprint 1
- Fine tune models
- Finish Engineering report
- Create Training pipeline essentials like Feature extraction functionality
- Attempt different feature selection methods(manual, automatic, ect)
- Create a working website, explaining motivation and linking to Git Repository
- Upload to Git Repository prediction Module Alpha version

Sprint 3: 01.03.24 - 29.03.24

- Close gaps and unfinished parts (if any) from Sprint 2
- Fine tune models
- write API
- Encase model in Module
- Ensure prediction Module operates within dummy system
- Upload Prediction Module only to Github (not training pipeline)
- Continuously update model encased in Module and update the API as training progresses and better models are created

Screenshot 5.1 - Trello 14.8.23



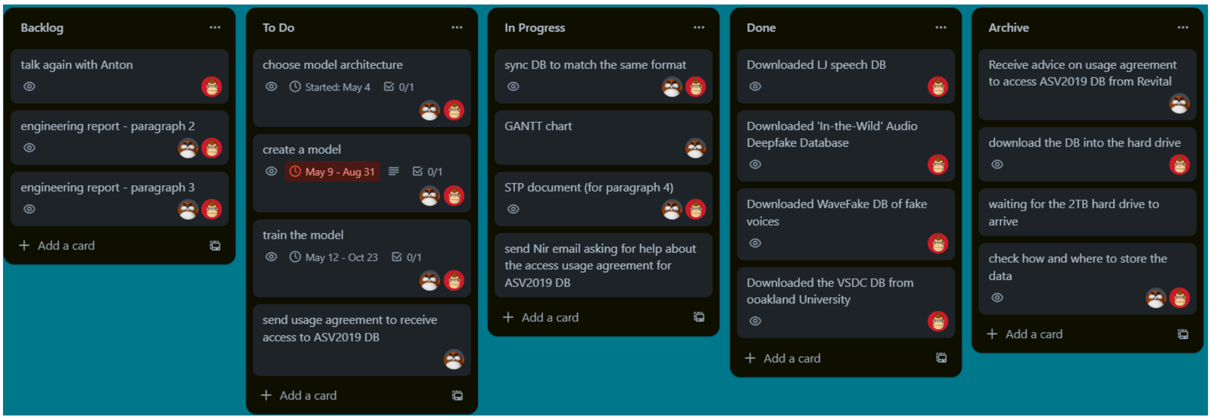
Backlog

- talk again with Anton
- engineering report - paragraph 2
- engineering report - paragraph 3
- GANTT chart
- STP document (for paragraph 4)

To Do

- check how and where to store the data
- choose model architecture — Started: May 4 — 0/1
- create a model — May 9 - Aug 31 — 0/1
- train the model

Screenshot 5.2 - Trello 06.09.23



Backlog

- talk again with Anton
- engineering report - paragraph 2
- engineering report - paragraph 3

To Do

- choose model architecture — Started: May 4 — 0/1
- create a model — May 9 - Aug 31 — 0/1
- train the model — May 12 - Oct 23 — 0/1
- send usage agreement to receive access to ASV2019 DB

In Progress

- sync DB to match the same format
- GANTT chart
- STP document (for paragraph 4)
- send Nir email asking for help about the access usage agreement for ASV2019 DB

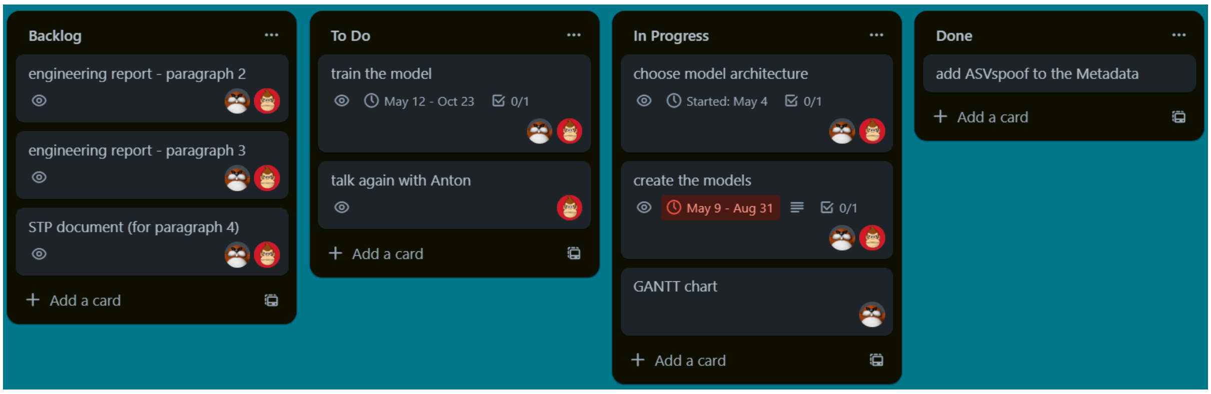
Done

- Downloaded LJ speech DB
- Downloaded 'In-the-Wild' Audio Deepfake Database
- Downloaded WaveFake DB of fake voices
- Downloaded the VSDC DB from ooakland University

Archive

- Receive advice on usage agreement to access ASV2019 DB from Revital
- download the DB into the hard drive
- waiting for the 2TB hard drive to arrive
- check how and where to store the data

Screenshot 5.3 - Trello 24.09.23



Backlog

- engineering report - paragraph 2
- engineering report - paragraph 3
- STP document (for paragraph 4)

To Do

- train the model — May 12 - Oct 23 — 0/1
- talk again with Anton

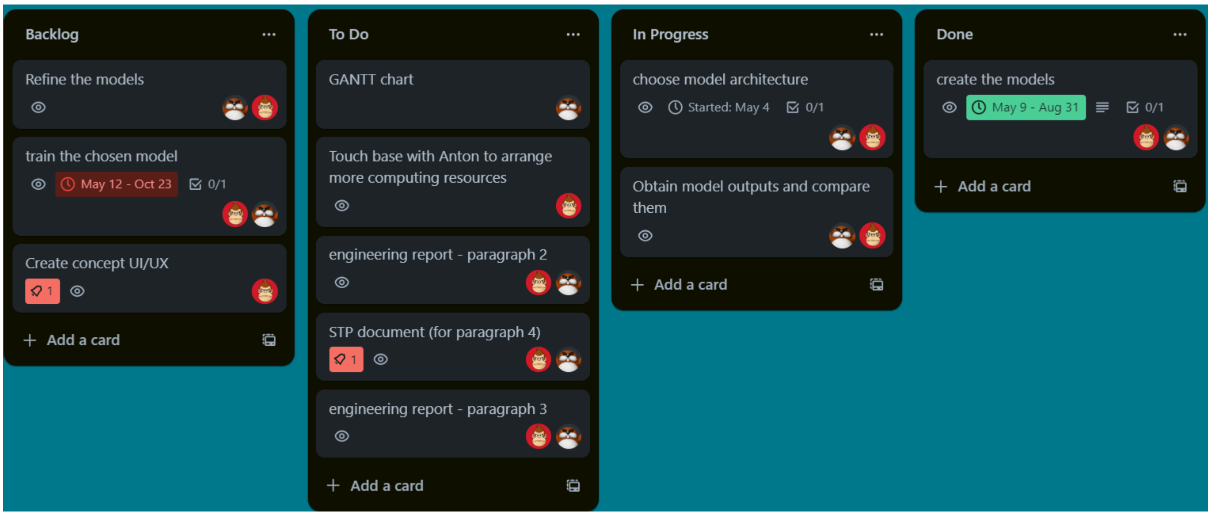
In Progress

- choose model architecture — Started: May 4 — 0/1
- create the models — May 9 - Aug 31 — 0/1
- GANTT chart

Done

- add ASVspoof to the Metadata

Screenshot 5.4 - Trello 31.10.2023



Backlog

- Refine the models
- train the chosen model — May 12 - Oct 23 — 0/1
- Create concept UI/UX — 1

To Do

- GANTT chart
- Touch base with Anton to arrange more computing resources
- engineering report - paragraph 2
- STP document (for paragraph 4) — 1
- engineering report - paragraph 3

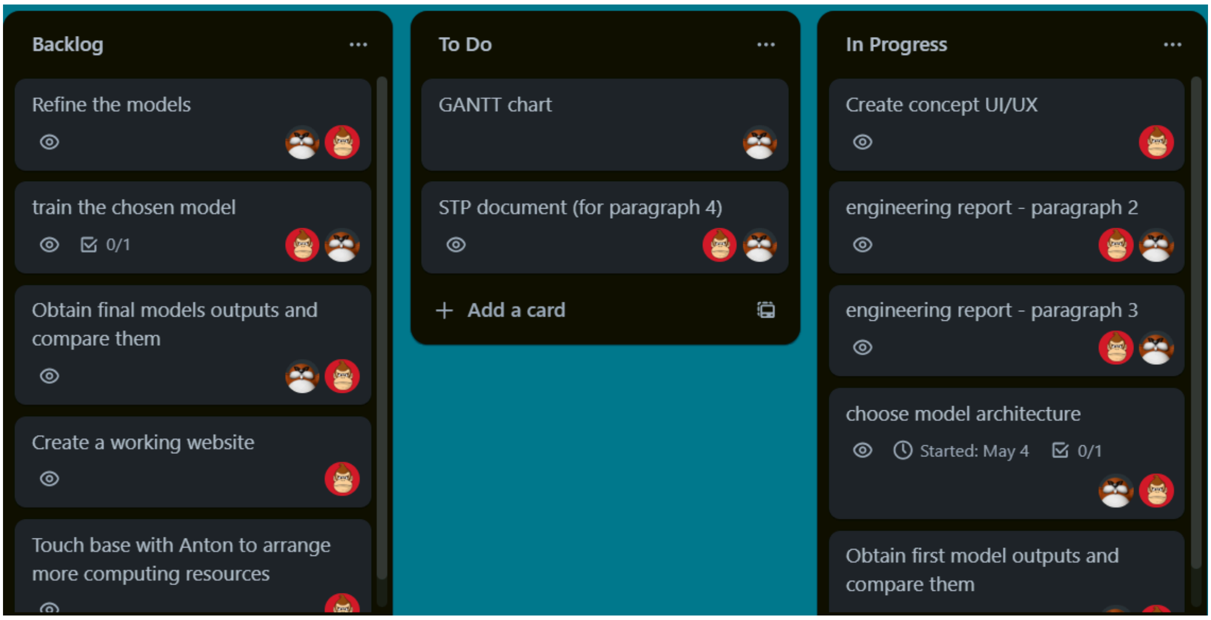
In Progress

- choose model architecture — Started: May 4 — 0/1
- Obtain model outputs and compare them

Done

- create the models — May 9 - Aug 31 — 0/1

Screenshot 5.5 - Trello 10.12.2023



Backlog

Refine the models

train the chosen model
0/1

Obtain final models outputs and compare them

Create a working website

Touch base with Anton to arrange more computing resources

To Do

GANTT chart

STP document (for paragraph 4)

+ Add a card

In Progress

Create concept UI/UX

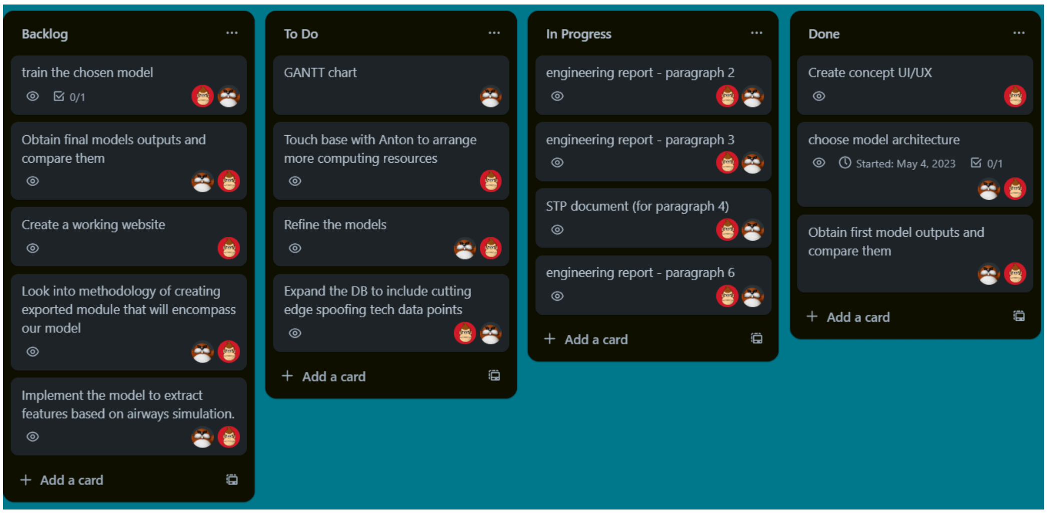
engineering report - paragraph 2

engineering report - paragraph 3

choose model architecture
Started: May 4 0/1

Obtain first model outputs and compare them

Screenshot 5.6 - Trello 14.01.24



Backlog

train the chosen model
0/1

Obtain final models outputs and compare them

Create a working website

Look into methodology of creating exported module that will encompass our model

Implement the model to extract features based on airways simulation.

+ Add a card

To Do

GANTT chart

Touch base with Anton to arrange more computing resources

Refine the models

Expand the DB to include cutting edge spoofing tech data points

+ Add a card

In Progress

engineering report - paragraph 2

engineering report - paragraph 3

STP document (for paragraph 4)

engineering report - paragraph 6

+ Add a card

Done

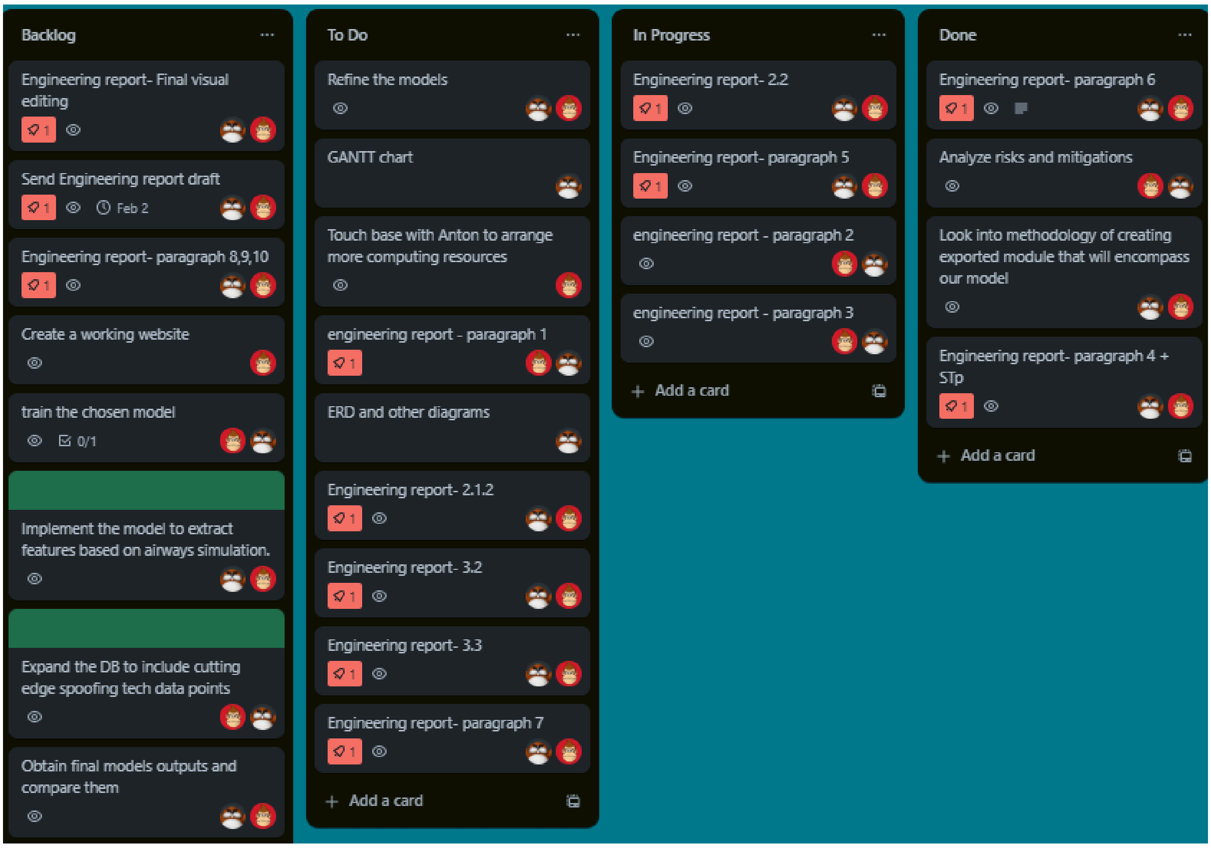
Create concept UI/UX

choose model architecture
Started: May 4, 2023 0/1

Obtain first model outputs and compare them

+ Add a card

Screenshot 5.7 - Trello 24.01.24



Backlog

- Engineering report- Final visual editing — 1
- Send Engineering report draft — 1 — Feb 2
- Engineering report- paragraph 8,9,10 — 1
- Create a working website
- train the chosen model — 0/1
- Implement the model to extract features based on airways simulation.
- Expand the DB to include cutting edge spoofing tech data points
- Obtain final models outputs and compare them

To Do

- Refine the models
- GANTT chart
- Touch base with Anton to arrange more computing resources
- engineering report - paragraph 1 — 1
- ERD and other diagrams
- Engineering report- 2.1.2 — 1
- Engineering report- 3.2 — 1
- Engineering report- 3.3 — 1
- Engineering report- paragraph 7 — 1

+ Add a card

In Progress

- Engineering report- 2.2 — 1
- Engineering report- paragraph 5 — 1
- engineering report - paragraph 2
- engineering report - paragraph 3

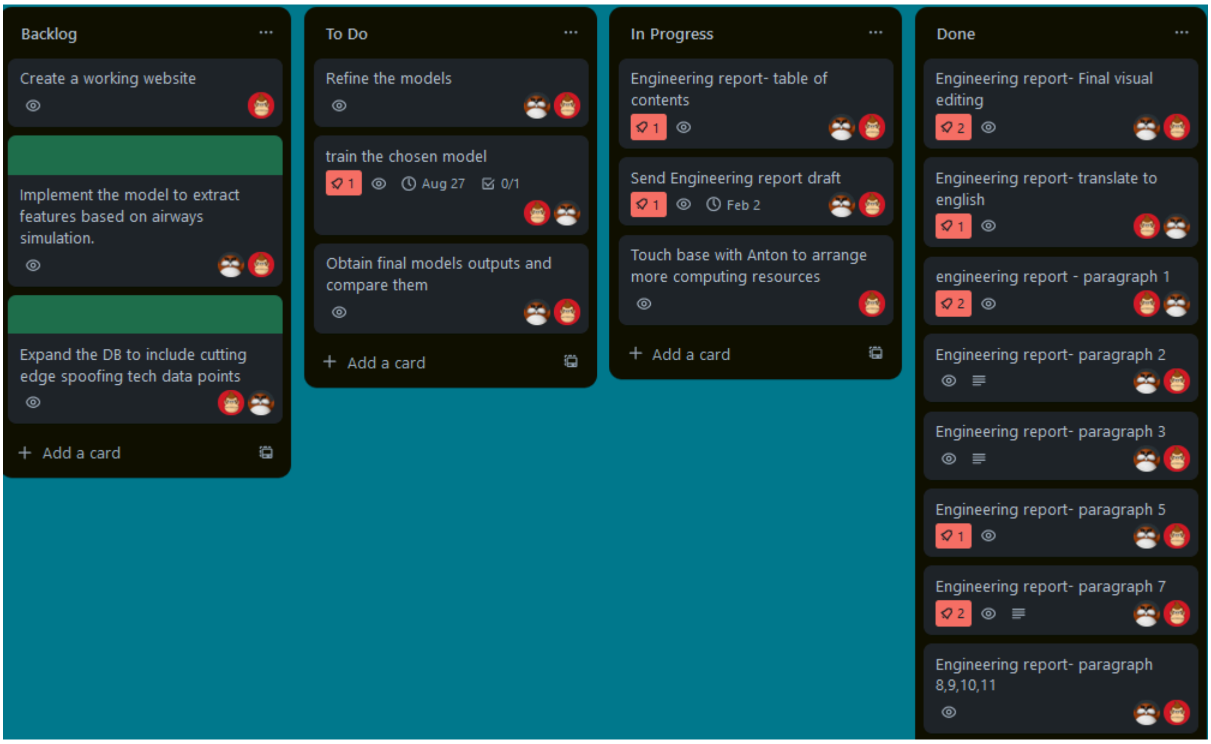
+ Add a card

Done

- Engineering report- paragraph 6 — 1
- Analyze risks and mitigations
- Look into methodology of creating exported module that will encompass our model
- Engineering report- paragraph 4 + STp — 1

+ Add a card

Screenshot 5.8 - Trello 01.02.24



Backlog

- Create a working website
- Implement the model to extract features based on airways simulation.
- Expand the DB to include cutting edge spoofing tech data points

+ Add a card

To Do

- Refine the models
- train the chosen model — 1 — Aug 27 — 0/1
- Obtain final models outputs and compare them

+ Add a card

In Progress

- Engineering report- table of contents — 1
- Send Engineering report draft — 1 — Feb 2
- Touch base with Anton to arrange more computing resources

+ Add a card

Done

- Engineering report- Final visual editing — 2
- Engineering report- translate to english — 1
- engineering report - paragraph 1 — 2
- Engineering report- paragraph 2
- Engineering report- paragraph 3
- Engineering report- paragraph 5 — 1
- Engineering report- paragraph 7 — 2
- Engineering report- paragraph 8,9,10,11

5.2. If there are changes in the schedules/tasks, they require the approval of the supervisor and the projector. Likewise, requests to change and/or postpone the schedules for submitting project deliverables.

- Following the terrorist attack on the State of Israel on the 7th of October, and the war of iron swords that broke out in its wake, the beginning of the semester was postponed several times and as a result several courses we relied on to obtain a professional background did not start at the planned time. In addition, the situation did not allow the team to meet regularly in order to work together on the project.

6. Risk management

6.1. As a reminder, risk is a factor, activity or situation that may endanger the course of the project, in any aspect: schedule, resources, technological barrier, lack of client involvement, administrative barrier, etc.

6.2. In this chapter, the main risks will be updated and detailed, most of which are mapped in the initiation document and materialized/not materialized as part of the submission of the engineering document, and ways of coping (in technical and administrative aspects only).

6.3. The information will be presented in a table: the description of the risk, the likelihood of realizing the level of potential damage/ its effect on the project, intensity (value of the intensity of the risk).

6.4. The risks will be defined and detailed according to the degree of likelihood of their occurrence and the weighting of the score of risk/likelihood/impact.

6.5. The risks will also be analyzed according to an index of a planned set of risk mitigation (risk mitigation) - the set of actions planned to minimize the effect of the risk if it materializes.

Table 6.1 - Risks management

Index	Major risks	Probability	Severity	Ways of mitigation	Damage intensity	Change reason
1	Use of an unreliable dataset or a dataset of a smaller then needed size	1	5	Finding a large and reliable dataset. Finding datasets from multiple origins. Altering and expanding the dataset. Combining datasets from multiple origins to create a diverse and wide singular dataset.	5	We have obtained a large and reliable database, and as such the risk is practically nullified
2	Training errors like Overfitting & Underfitting	2	2	Altering the model by adding ‘noise’. Changing the parameters used. Alter the chosen features in the model. Choosing a different model architecture. Use of feature-select algorithms.	4	After obtaining a large and varied dataset, we are confident about preventing overfitting.
3	This field is cutting edge and new and as such there will be a lack of papers & information sources about it	2	3	Conduction of a thorough literature review. Researching faking tools and investigating them. Having “a finger on the pulse” as the development process continues in order to be up to date with the tech throughout the project.	6	we saw that there are many articles related to the subject on the internet, but most of them regurgitate the same information (about the AI algorithms and architecture)

4	A lack of professional and industry standard in writing code of this field	2	3	Adherence to regular machine learning writing conventions with respect to needed changes. Analysis of similar algorithms and extraction of patterns. Setting a personal standard and keeping to it throughout development.	6	We found a few standards of writing for tools such as CNN and MEL spectrograms, however we didn't come across information about other tools we require, as such the probability lowered, but severity rose
5	Difficulties in validating new audio files that were created by using new technologies to create deep fake voices	5	3	Usage of proper datasets. Creating an independent database. Creating a model that doesn't rely on catching specific faking tools but rather can work for any. maintaining the code and updating the model.	15	We saw in real time advancements in spoofing technology, and have taken to expanding our training dataset already.
6	Permission to use recorded voice	1	5	Requesting appropriate permissions. Finding other and accessible sources. Use of existing datasets which have existing permissions.	5	We obtained databases with pre given permission, as such this is now a null-risk

7	High prediction errors like FP or low accuracy scores like F1	4	4	Improving the model and polishing it over an extended period of time Use a wide range of faked voices as well as real voice samples Alter the parameters, features, architecture and ect. In order to improve the needed scores	16	This risk hasn't changed, as it is an integral part of ML. The big part of understanding ML is attempting to mitigate this risk.

7. High Level Design of the Alpha version

7.1. The Alpha version is a representative version (demo) that reflects the main contents, processes and algorithms of the system planned as part of the project.

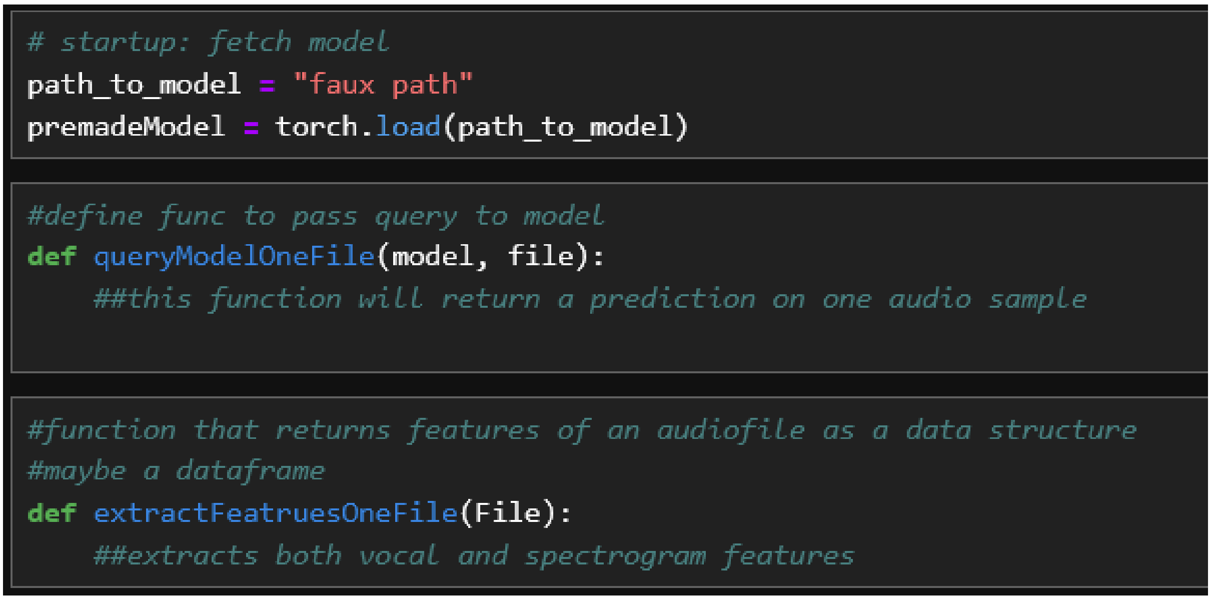
- The Alpha version will function as an AI module, allowing users or security companies to upload an audio file and receive a binary output indicating whether the voice is classified as real or fake.

7.2. This version will be used as a basis for the implementation and demonstration of core principles and processes of the planned system within the project.

- The purpose of the Alpha version is to assess the functionality and reliability of the AI module. It serves as a testing ground to identify strengths and potential issues in the implemented AI, helping to refine and optimize its performance.

7.3. The "Alpha Planning" chapter will contain a brief description, in structured English and Pseudo Code, of the principles and contents intended for implementation in the Alpha version (detailed planning and implementation will only be in the framework of the final engineering report, hereinafter the "Project Book"), when this "Planning" chapter will be planned and written According to these basic lines:

- The pseudo code to follow will show a brief insight to the inner working of our end goal, a spoof-detecting module that can integrate into larger systems. In Pseudocode example 7.1 you can see the already saved and trained model prepared in the development environment being loaded, and the functions that help query be defined. In Pseudocode example 7.2 you can see the query occur.

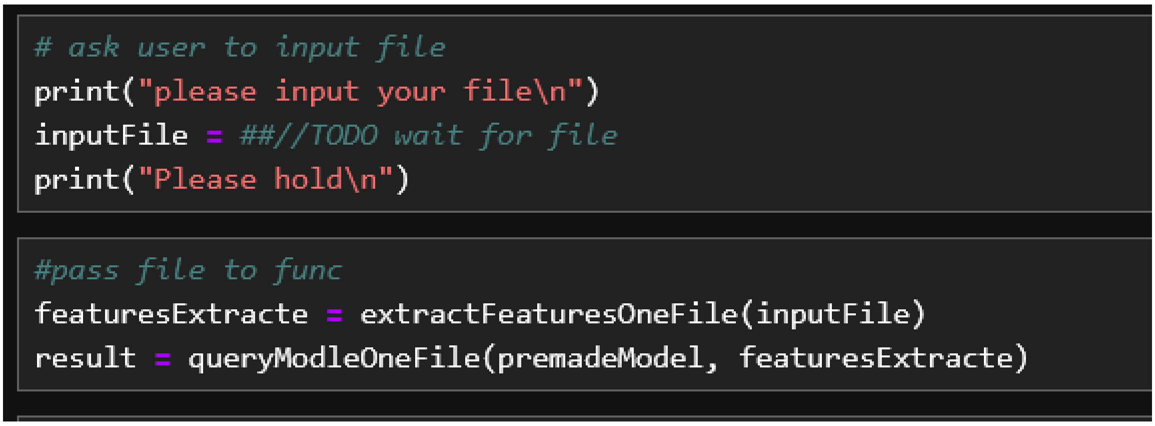


```
# startup: fetch model
path_to_model = "faux path"
premadeModel = torch.load(path_to_model)
```

```
#define func to pass query to model
def queryModelOneFile(model, file):
    ##this function will return a prediction on one audio sample
```

```
#function that returns features of an audiofile as a data structure
#maybe a dataframe
def extractFeatruesOneFile(File):
    ##extracts both vocal and spectrogram features
```

Screenshot 7.2 - Pseudocode Example



```
# ask user to input file
print("please input your file\n")
inputFile = ##//TODO wait for file
print("Please hold\n")
```

```
#pass file to func
featuresExtracte = extractFeaturesOneFile(inputFile)
result = queryModleOneFile(premadeModel, featuresExtracte)
```

Screenshot 7.3 - Pseudocode Example

7.3.1. The basis: the system architecture (see above).

- The Alpha's architecture is designed as a black box for users, concealing the internal code and AI processes. Users interact with it by providing input (audio file) and receiving a boolean output without knowledge of the underlying workings. See Pseudocode examples 7.1 and 7.2

7.3.2. Scripts based on the main usage scenarios of the planned system.

- A common scenario involves a security company using the Alpha to verify the authenticity of an audio file, such as a person attempting to access their account by confirming their identity through voice verification.

7.3.3. Screens or GUI of the main processes.

- User interaction with the system is minimal, reflecting the straightforward process of uploading an audio file and receiving the authenticity output. There shouldn't be any direct User - System interaction, as the system acts as a module within a larger system with its own GUI

7.3.4. Interfaces between modules and processes, including reference to the system architecture.

- The primary interaction involves communication between the larger system and the AI module, with minimal dependencies on external modules or processes.

7.3.5. Demonstration of link and connection to the modules and architecture of the complete system planned for implementation.

- The Alpha version demonstrates its link to the complete system by showcasing its potential as a standalone module with the capability to provide its functionality through an API.

7.3.6. The algorithms planned for implementation within the planned system.

- Within the Production Module Algorithms beyond feature extraction aren't present. The algorithms are present within the training pipeline as learning algorithms.

8. Discussion

8.1 In this chapter, there will be an update of the main points of the discussion and thinking and a breakdown of the status of the project, its stages, the difficulties faced and compliance (or non-compliance) with the schedule (with reference to the engineering report).

Project Status:

- Utilized the ASVspoof2019 database for comprehensive model training, ensuring exposure to a diverse range of voice samples.
- Advanced the development of the core functionalities, focusing on voice classification, real-time processing, voice screening, and speaker identification.
- Continued refinement of the model's code, with an emphasis on optimizing performance and accuracy.

Next Steps:

- Complete the model, including fine-tuning and optimizing hyperparameters for enhanced accuracy.
- Develop a functional website for the project, facilitating easy access and download for users.
- Prepare for the subsequent upload of the project and its components to GitHub for wider accessibility and collaboration.

Difficulties Encountered:

- The complexity of voice classification, especially in handling diverse accents and languages, posed challenges during the implementation phase.
- Fine-tuning the feature extraction process to capture subtle nuances while maintaining accuracy presented difficulties.
- The ongoing war in the country since October has led to delays in project work, as the college schedule was affected, and initial mental health challenges were experienced.

Delays in the Schedule:

- Complexity of the Problem: The intricate nature of detecting fake voice audio in real-world scenarios contributed to the extension of development and testing timelines.
- Iterative Development: The iterative nature of refining the model's code and algorithms necessitated additional time for optimization.
- Technical Challenges: Unforeseen technical hurdles in integrating with external systems and ensuring compatibility with various audio formats required adjustments.
- War-Related Delays: The ongoing war in the country since October led to disruptions in the college schedule and initial mental health challenges, contributing to delays in project work.

Compliance (or Non-Compliance) with the Schedule:

- While there have been deviations from the initial schedule outlined in the engineering report, they are contextualized by the dynamic nature of AI development, the need for constant adaptation to emerging threats, and external factors such as the ongoing war.

9. Summary and conclusions

9.1 In this chapter, an update of the conclusions and lessons for the continuation of the project will be presented.

This engineering report presents the development and implementation of a Voice Spoofing Detection system using Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks. The project aimed to enhance the security of voice-based authentication systems by accurately distinguishing between genuine and spoofed voices. The Alpha-level design involved a meticulous consideration of both architectural and algorithmic components, leveraging the strengths of CNNs for feature extraction and LSTMs for capturing temporal dependencies in voice data.

The system architecture was designed with a multi-layered approach, incorporating CNN layers for initial feature extraction, followed by LSTM layers to analyze sequential patterns in voice samples. This hybrid architecture proved effective in addressing the challenges posed by voice spoofing attempts, demonstrating robustness in discerning subtle nuances that distinguish genuine voices from fabricated ones.

One notable aspect of the project was the creation of a self-built database, which played a pivotal role in training and validating the machine learning models. The database, locally stored on an external hard disk, comprised a diverse set of voice samples, including various accents, intonations, and environmental conditions. This approach ensured a comprehensive training dataset.

The development environment utilized JupyterLab as the primary platform for model development and experimentation. The interactive and collaborative nature of JupyterLab facilitated seamless iteration and testing of different network architectures and hyperparameters. This choice of development platform contributed to the efficiency and agility of the project, allowing for quick adaptation to emerging challenges and insights gained during the development process.

In conclusion, the integration of CNN and LSTM networks in our Voice Spoofing Detection system has proven to be a potent solution for enhancing the security of voice-based authentication systems. The Alpha-level design, meticulously crafted with a hybrid architecture, successfully addressed the intricate challenges posed by voice spoofing attempts. The utilization of a self-built database, stored locally on an external hard disk, ensured a rich and diverse training dataset, contributing to the robustness and generalization capabilities of the deployed models.

The choice of JupyterLab as the development platform streamlined the model development process, allowing for rapid iteration and experimentation. The collaborative and interactive nature of JupyterLab proved instrumental in adapting to evolving requirements and refining the models for optimal performance. Overall, the successful implementation of this Voice Spoofing Detection system underscores the potential of combining CNN and LSTM networks, emphasizing the significance of meticulous database construction and a flexible development platform in the pursuit of robust and effective machine learning solutions.

10. References

10.1 As part of updating the sections of the literature survey, the students must research, deepen and review scientific sources relevant to the project and the planned system: scientific articles, books and official or professional websites. As a reminder, the update of the literature survey will be based on sources in Israel and abroad. Next to each item cited in the text, its sources will be mentioned, according to the rules of writing and presentation detailed in Appendix E to the project procedure.

In view of the fact that at the beginning of the project, about 11 academic articles were purchased, as well as the content in them being comprehensive regarding the material, it was not necessary to find additional sources.