Emotion Recognition in Texts using Deep Learning Techniques

INTERNSHIP REPORT

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Dr. Alaa Mohasseb, Senior Lecturer

Thomas Chu

2nd year of a Bachelor's degree program in Computer Science

Ingrid Couturier, IUT Tutor

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Acknowledgments

I would like to express my deepest gratitude to my internship supervisor, Dr. Alaa Mohasseb, for their exceptional support and guidance throughout my journey in the field of machine learning. Dr. Mohasseb's availability and insightful discussions have been invaluable to my work. Moreover, I am grateful for the courses she provided me, which significantly enriched my understanding of machine learning concepts. Her kindness and patience in answering my numerous questions have made this learning experience truly worthwhile.

I would like to extend my heartfelt appreciation to Enguerrand Boitel, a PhD student whom I had the privilege of working with during my internship. Mr. Boitel's expertise and knowledge of machine learning techniques truly shaped my current understanding of this complex field. His guidance has been invaluable in developing my skills in model tuning, and data analysis. I am forever grateful for his dedication and for imparting his knowledge generously.

I would also like to express my sincere appreciation to all my teachers at IUT Nord Franche-Comté for their contribution to my education in computer science. Their dedicated teaching has played a pivotal role in equipping me with the necessary tools and knowledge to adapt swiftly to the challenges of machine learning. I am grateful for the knowledge they have given to me during my two years of formation.

Last but not least, I would like to acknowledge Mrs. Ingrid Couturier, my tutor, as without her unwavering support, this internship in England would have never been possible. Ms. Couturier's availability and willingness to assist me in various aspects have been truly commendable during this internship, but also throughout the two years of my formation at IUT Nord Franche-Comté.

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Introduction

In recent years, the recognition of emotional intelligence in education has grown significantly with research[1] indicating that a student's emotional state and well-being has a substantial impact on their academic performance. Acknowledging this correlation, educators have sought to understand and address students' emotions to provide personalized support and interventions, ultimately leading to improved learning outcomes. Advanced technologies, such as emotion recognition models, have emerged as valuable tools in this endeavor.

The University of Portsmouth's IT department invited me to collaborate on a research project led by PhD student Enguerrand Boitel. This project had already been initiated by Mr. Boitel and two French interns from IUT Nord Franche-Comté, who had worked on it the previous year. The project aimed to develop a highly accurate prediction model capable of determining emotions expressed in recorded data. The goal is to provide teachers with crucial feedback on individual students' emotions, thereby enhancing their ability to offer tailored support. As an intern in the IT department, my specific task was to create a prediction model that specializes in analyzing emotions in text data. Furthermore, I aimed to compare the performance of my model against existing ones developed by my predecessors.

I opted for this internship with the intention of securing a position in the field of data science. Although I had a strong interest in working in a machine learning project, I understood the importance of being open to various opportunities. When I discovered that I had been accepted to work on an intelligent sentiment analysis project in England, I was overwhelmed with excitement and wasted no time in accepting the opportunity. My time studying in Canada last year taught me a valuable lesson – the significance of seizing opportunities like the one I had there. The experience of delving into a new realm of data science, which I will undoubtedly encounter in future projects, embracing novel work methodologies and immersing myself in diverse cultures was an opportunity I couldn't afford to miss.

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1 Natalio Extremera, Ph.D. Researcher of the Faculty of Psychology at University of Malága in particular found positive results regarding the use of emotional emotional intelligence on academic performance in adolescents. You can find links to some of his research in the sitography down below.

Throughout this internship report, I will share my experiences, discoveries, and findings in the field of emotion recognition. I encountered various difficulties and challenges as I explored this fascinating area of study in depth. My hope is to illuminate the immense potential that models like ours hold in transforming education and improving students' academic performance.

1 Presentation of the University

The University of Portsmouth holds a steadfast commitment to its core purpose of providing a transformative educational experience for its students. With a diverse range of schools and faculties, including the Portsmouth Business School, Faculty of Technology, Faculty of Science, Faculty of Humanities and Social Sciences, and Faculty of Cultural and Creative Industries, the university offers a comprehensive and well-rounded education across various disciplines.

The university located in England in the city of Portsmouth is split between the University Quarter, which is centered around the Portsmouth Guildhall area, and the Langstone Campus[2].

The University of Portsmouth takes pride in its commitment to research excellence. Through cutting-edge and academic collaborations, this institution contributes to advancements in knowledge, addresses societal challenges, and makes a meaningful impact on local and global communities. By fostering a culture of curiosity, intellectual exploration, and interdisciplinary collaboration, the university encourages its students and faculty to push boundaries and contribute to the advancement of knowledge in their respective fields.

2 cf. Annex I: Portsmouth University Location.

2 Subject presentation

2.1 The team

During my internship, I was based in the Faculty of Technology[3] within the School of Computing[4] at the University of Portsmouth.

Illustration 1: Buckingham Building - School of Computing

Within this academic setting, I worked in a dynamic research office where numerous PhD students pursued their research under the guidance of different lecturers. Specifically, I had the privilege of being assigned to Senior Lecturer Dr. Alaa Mohasseb as my internship supervisor. Alongside me, Julien Oudot, a fellow student from IUT Nord Franche-Comté, was also part of our research office. Together, we had the unique opportunity to support Enguerrand Boitel, a PhD student, in advancing his thesis. Working under the guidance of Dr. Mohasseb, our collective efforts contributed to the progress of Mr. Boitel's research work.

3 cf. Annex II: Organigram from the Head of the faculty of Technology of the University of Portsmouth to us interns.

4 cf. Annex III: Portsmouth University Campus. The School of Computing is in the Buckingham building, the fourth building on the map.

2.2 The thesis

The field of artificial intelligence has seen a growing interest in human emotion recognition, making it a prominent topic in scientific research. Remarkable advancements have been made in this area, particularly in understanding how emotions can be expressed through various mediums such as voice, hand gestures, body language, and facial expressions. The expressions on a person's face can provide valuable insights into their cognitive processes and offer a glimpse into their inner thoughts and feelings. The aim of emotion recognition is to equip computers with the ability to perceive and analyze human emotions in a manner similar to how humans do.

Considerable progress has been made in emotion recognition for specific types of data, such as text, audio, and images. However, an intriguing area that remains unexplored is the integration of motion-based emotion recognition analysis with these existing approaches. This means combining the analysis expressions with the analysis of text, audio, and images to gain a more comprehensive understanding of human emotions.

2.3 My main objective

In the context of Mr. Boitel's thesis on emotion recognition, my primary mission was to develop a prediction model specifically focused on analyzing text-based expressions of emotions. Recognizing the limitations of time and resources, we decided to narrow our scope to the textual domain to ensure a thorough and in-depth analysis within the available time frame.

The objective behind this mission was to contribute to Mr. Boitel's research by creating a text-based prediction model that could be compared and contrasted with his existing approach. By having multiple models dedicated to different modalities, such as text, audio, and images, we aimed to explore the strengths, weaknesses, and potential synergies of these various approaches in emotion recognition.

3 Internship progression

3.1 Specifications

There were no strict specifications or predefined guidelines assigned to me during this internship. The role given to me was focused on assisting Mr. Boitel with his thesis, embracing a collaborative and adaptive approach. Without rigid specifications dictating my tasks, I had the opportunity to actively contribute and generate ideas throughout the internship. Our workflow followed a dynamic process, with Mr. Boitel assigning weekly tasks and me presenting results, discussing them, and determining the next steps in our daily interactions. I had the freedom to explore diverse avenues, experiment with different approaches, and leverage my creativity and problem-solving skills. This approach fostered a sense of ownership, allowing me to contribute actively to the project's development.

3.1.1 Operating system

I had the freedom to choose the operating system for my work, without any specific constraints.

3.1.2 Programming languages

I also had the freedom to choose the programming language for this project, without any imposed limitations or constraints.

3.1.3 Model features

The development of the model however, was subjected to a minor limitation for accuracy reasons. According to the data that was available for training, it was required to predict emotions from text, specifically focusing on Paul Ekman's[5] seven main emotions: Anger, Contempt (referred to as 'Neutral' in our case), Disgust, Enjoyment (Happiness), Fear, Sadness, and Surprise.

5 Paul Ekman is an American Emotion Psychologist that discovered that some facial expressions of emotions are universal while many of the apparent differences in facial expressions across cultures were due to context. He also co-discovered micro facial expressions.

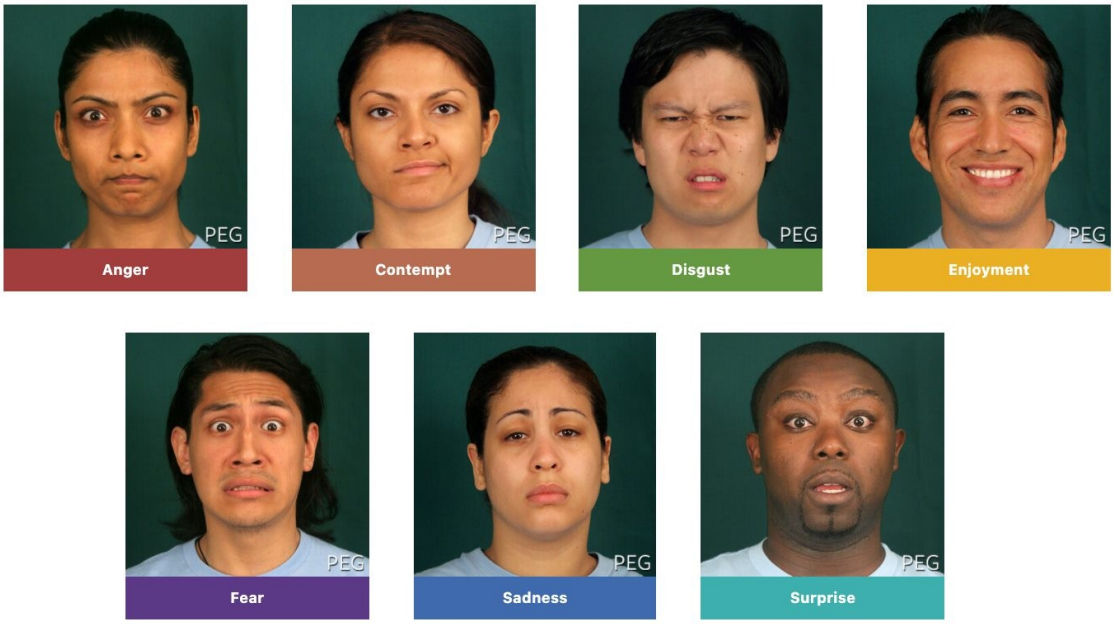

Illustration 2: Ekman's seven main emotions

3.2 Implementation

3.2.1 Operating system

As someone new to machine learning, I wasn't sure which operating system would be most suitable for the tasks assigned to me. However, considering the fact that I developed my models using Google Colab[6], the choice of operating system should not have a significant impact. Although I am more familiar with a Linux environment, I opted for Windows for performance issues. Since machine learning tasks require substantial computing power, I found that my personal computer running Windows offered superior CPU[7] and GPU[8] performance compared to my work computer running Linux.

6 Google Colab, short for Google Colaboratory, is a cloud-based platform provided by Google. It offers a Jupyter Notebook environment that allows users to write and execute Python code in a browser making it a great tool for machine learning tasks.

7 Central Processing Unit: the main processor in a computer, having a better CPU means the computer can think and work faster.

8 Graphics Processing Unit: a specialized processor optimized for parallel computing, making it ideal for machine learning tasks that involve large-scale computations.

3.2.2 Programming languages and tools

After conducting thorough research and considering the insights from the books I have read, it became clear that there is no definitive “best” programming language for machine learning. Each language has its strengths and is suitable for a specific applications. However, during my internship, I received valuable guidance from Dr. Mohasseb, who provided me with books that taught me machine learning concepts using Python. Furthermore, Mr. Boitel had been developing his models using Python on Google Colab.

Examining the trends and preferences among machine learning engineers, it appeared that Python was widely used for NLP[9] tasks. Additionally, both Python and R[10] were commonly utilized for sentiment analysis tasks. Considering these factors, I made the decision to work with Python for my internship project.

One crucial aspect that influenced my choice was the familiarity and expertise of my supervisors in Python. They had extensive experience with the language, making it easier for them to provide guidance, support, and valuable insights throughout the development process. Their proficiency in Python facilitated effective collaboration and allowed me to receive prompt assistance whenever needed.

Finally, I also chose to use Jupyter Notebook[11] for my internship project because of its versatility, interactivity, and seamless integration of code, visualizations, and explanations. It allowed me to leverage various programming languages, easily modify and rerun code cells, and documents my methodology effectively. This decision facilitated iterative development and accelerated the machine learning process.

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9 Natural Language Processing: an interdisciplinary subfield of linguistics, computer science and artificial intelligence concerned with the interactions between computers and human language.

10 R is a language and environment for statistical computing and analysis, Python is easier to use and read.

11 Jupyter Notebook is a server-client application that allows editing and running notebook documents via a web browser. It can also be executed on a local desktop requiring no internet access.

3.2.3 Preliminary preparations

At the beginning of the internship, I faced a delay in commencing programming tasks. One contributing factor was my arrival during the middle of the Easter vacation, which meant that Dr. Mohasseb and Mr. Boitel were not available at the university. However, even if they were present, I wouldn't have been able to begin coding immediately because I needed to acquire a comprehensive understanding of machine learning concepts before diving into writing any code.

I dedicated two weeks to learn the fundamental concepts of Machine Learning. During this time, Dr. Mohasseb generously shared her extensive data science and machine learning courses, which encompassed an impressive 22-week curriculum. Additionally, she kindly recommended a selection of books for me to delve into and further expand my knowledge.

Naturally, the two-week period proved insufficient for me to fully comprehend the extensive knowledge required to effectively support a PhD student in developing a highly accurate emotion recognition model. However, I eagerly embraced the challenge and continued my learning journey. Even as I embarked on the true objective of my internship, which involved programming my very first model, I kept the books and courses within close reach for continuous reading and reference.

3.2.4 Programming a model for emotion recognition in text

The beginning of the prediction model development for NLP-based emotion recognition entails several critical components. The first key element is the utilization of a diverse and meticulously curated dataset, which serves as the foundation for training and evaluating the model. With this in mind, I will now proceed to describe the dataset that was employed in this process.

3.2.4.1 BAUM dataset

The BAUM dataset provides a valuable resource for affective computing applications[12], offering access to labeled spontaneous affective data. Unlike many existing databases, which consist of acted data or lack audio recordings, the BAUM dataset comprises audio-visual recordings of individuals expressing various affective and mental states. The recordings capture subjects' reactions to carefully designed images and video clips, evoking a range of emotions and mental states. Subjects were given the freedom to express their thoughts and feelings about the stimuli in an unscripted and unguided manner in Turkish.

Illustration 3: The 31 subjects who volunteered for the recordings of BAUM-1 database. All subjects (except subject 5) gave their consent for their images to be used in publications.

That dataset includes a diverse set of emotions, including the six basic ones (happiness, anger, sadness, disgust, fear, surprise), as well as boredom and contempt. Additionally, it targets several mental states such as unsure (including confused and undecided), thinking, concentrating, and bothered. The data was collected from 31 participants, consisting of both male and female subjects. Prior to each recording session, subjects were provided with detailed explanations of the procedure and were given the options to withdraw at any point. Consent forms were signed, allowing the use and sharing of recordings for research purposes.

12 Affective computing is the study and development of systems and devices that can recognize, interpret, process, and simulate human affects.

It is important to note some limitations of the emotions elicitation process. Due to the awareness of being recorded, subjects may not express completely spontaneous emotions, leading to some suppression or exaggeration. Additionally, inducing fear proved challenging in a secure office environment, as reported in previous studies. Another difficulty encountered was the discreteness of emotions, as multiple emotions or mental states often coexist. These observations highlight the complexities involved in accurately capturing and labeling emotions.

To ensure consistency and enhance accuracy, we aimed to simplify and standardize the emotions. To accomplish this, we referred to the emotion wheel[13] concept. We mapped the different emotions in the dataset to the seven basic emotions proposed by Paul Ekman (happiness, anger, sadness, disgust, fear, surprise and neutral), condensing the emotional spectrum into a consistent framework. This conversion process allowed us to focus on these core emotions and improve the precision of our emotion recognition model.

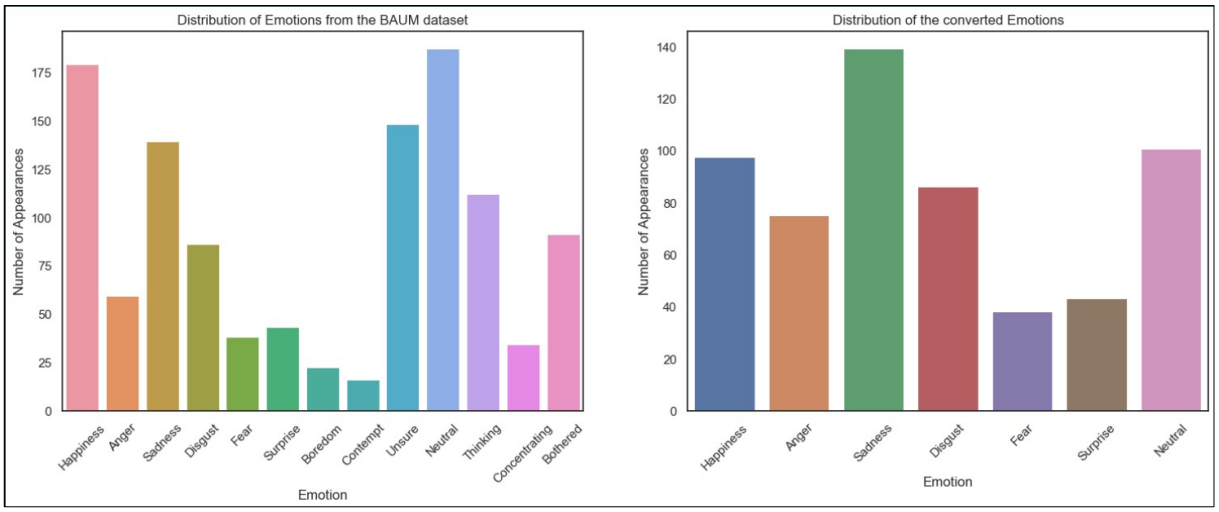

Illustration 4: Comparing Emotion Distributions: Original vs. Emotion Wheel Conversion

13 cf. Annex IV: Emotion Wheel

3.2.4.2 Data preprocessing

Once the BAUM dataset is collected and prepared in our code, the next step in creating an NLP model for emotion recognition begins. This phase involves working with the textual data to remove any excess information and enhance the data's relevance for the model by employing preprocessing techniques. These techniques play a significant role in transforming the raw data into a clean and optimized format, laying the foundation for subsequent model development:

- Tokenization: Breaking down text into individual tokens or words. This enables the model to understand and process the textual data at a granular level.
- Lowercase conversion: All the text is transformed to lowercase. This normalization technique helps to ensure consistency in the data and avoids potential discrepancies that may arise from differences in letter case.
- Removing common words: Stopwords, numbers, digits, special characters, symbols, URLs or HTML tags. They do not carry significant meaning in the context of sentiment analysis or emotion recognition. It allows the model to focus on more meaningful and informative words.
- Stemming: Reducing words to their base or root form (e.g., "writing" to "write").
- Spell checking: Correcting misspelled words in text.

By applying these preprocessing techniques, the data is refined, noise is reduced, and the text is standardized for further analysis. This clean and optimized data serves as a solid starting point for developing and refining the NLP model for emotion recognition, ensuring accurate and reliable predictions. I actually spent a lot of time tinkering with my model to improve its accuracy, and I found that tweaking and experimenting with different preprocessing techniques had a noticeable impact on the results. Adding or removing specific techniques made a real difference in improving the accuracy of my model.

3.2.4.3 Training a prediction model

Choosing the right model or protocol for our machine learning (ML) project is crucial and depends on the specific objective we aim to achieve. There are various models available, such as linear regression, k-mean, or Bayesian, each suited for different types of data. For example, convolutional neural networks are ideal for image processing tasks, while k-means works well for segmentation purposes. We chose to utilize the BERT model and an OpenAI Davinci model. These models were selected based on their overall performance and ability to meet our project requirements effectively.

Once the model was selected, the next step was training it with the BAUM dataset we prepared. This training stage allows the ML algorithm to learn and improve its prediction capabilities. Consistent training plays a vital role in enhancing the model's accuracy, and it involves initializing the model's weights randomly, enabling the algorithm to adjust them effectively.

To evaluate the model's performance, we needed to test it against a separate dataset called the "validation dataset". This evaluation helped us assess the accuracy of the model and define the measures of success. It was crucial to align these measures with the intended objectives of the model to establish a meaningful correlation.

Fine-tuning is another important aspect of our model development. By selecting and modifying the right parameters, known as hyperparameters, we can achieve accurate correlation. We carefully observed and recorded the hyperparameters and the prediction behavior of the model in a notebook. This process proved to be valuable in enhancing both the accuracy and overall performance of our models.

3.2.4.4 Final results

Throughout the internship, a major focus was on enhancing the performance of the existing BERT models created by Mr. Boitel and the previous interns. This effort aimed to improve their already impressive accuracy of 84,7% while providing an opportunity for me to learn from established instructions and techniques. Starting as a beginner in machine learning, this experience deepened my understanding of natural language processing. Later in the project, we also worked on an OpenAI Davinci model.

After investing considerable time in troubleshooting and refining the fine-tuning process, we successfully improved the performance of the Davinci model. It achieved an impressive accuracy of 88,11% on entire BAUM dataset, providing Mr. Boitel with an additional high-performing model for his comparative analyses.

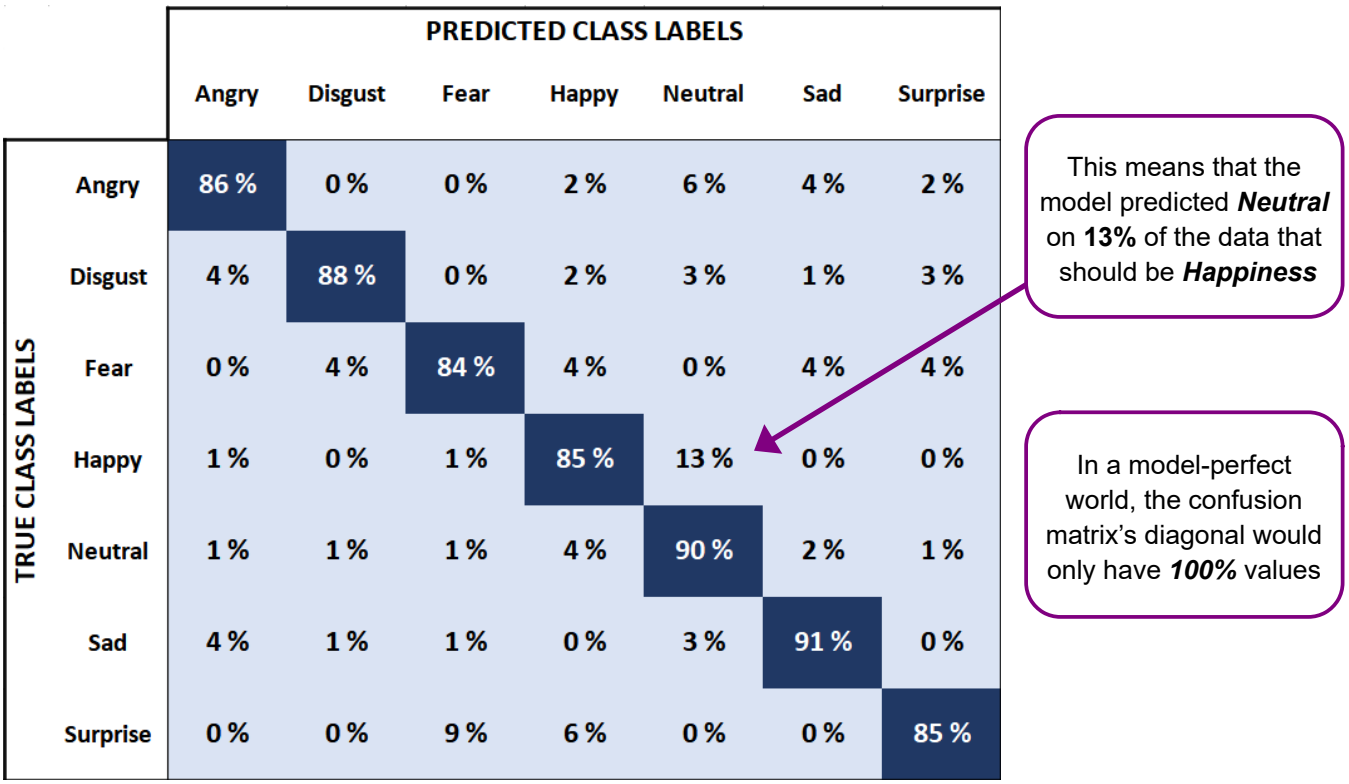

Illustration 5: Confusion matrix of the fine-tuned Davinci model on the BAUM dataset

One notable advantage of the fine-tuned OpenAI model is its faster prediction speed when compared to BERT. This attribute can be particularly advantageous for time-sensitive applications or tasks that involve real-time processing of substantial amounts of text data. It is important to mention, however, that the outputs generated by the fine-tuned model does not always align with the desired representation of the seven emotions we aimed to capture.

Furthermore, to evaluate the performance of both the fine-tuned OpenAI model and BERT, we tested them on other datasets obtained from Kaggle[14]. Unfortunately, their performance on these datasets did not meet the promising results achieved on the BAUM dataset. While the models provided coherent responses, they did not precisely match the expected outputs. It is worth noting that from a human perception standpoint, the reasoning behind the model's responses is understandable. However, they did not consistently align exactly with the desired output.

3.2.5 Another mission entrusted to me during the internship

During the later part of my internship, I undertook an additional mission at the request of Mr. Boitel, which involved exploring the capabilities of an automatic speech recognition system called Whisper, developed by OpenAI. Whisper demonstrated impressive accuracy in transcribing pre-recorded speech into text, making it a promising tool. However, when it came to a real-time application like live sessions, the system encountered frequent crashes and instability, posing challenges for its integration. As a result, we relied on Julien Oudot's existing solution, which prove to be more reliable for live speech-to-text conversion.

14 Kaggle is a platform for data science where you can find datasets, notebooks, competitions, courses and more.

4 Assessments

4.1 Human assessment

During the course of my internship, I had the privilege of forming and nurturing exceptional relationships with the entire team. Working closely alongside Mr. Boitel, a seasoned researcher, provided me with a fresh outlook on collaborative work that diverged from the projects I had previously undertaken during my university studies.

Interacting with Mr. Boitel, a PhD student in computer science who shared a similar educational background, including being a former IUT graduate and a former French *prépa*[15] student, proved to be an invaluable experience. Our working dynamic was exceptional, and his distinct approaches to studying and learning, in contrast to what I had encountered in France, expanded my knowledge and provided ample opportunities for me to practice expressing myself in English. This experience significantly contributed to my overall growth and proficiency in the English language, particularly in conversing with native speakers.

Throughout my time at the university, I was continually impressed by Mr. Boitel's dynamism, expertise, passion and unwavering dedication. Engaging with him was truly exhilarating, and I genuinely aspire to maintain contact with him even after completing my internship, despite the physical distance that separates us.

Overall, the internship offered me an immersive and enriching environment, allowing me to forge meaningful relationships, glean insights from diverse perspectives, and be inspired by the unwavering enthusiasm of the researchers I worked alongside.

4.2 Thesis assessment

During my internship, Mr. Boitel and I made significant progress in our collaborative work, which will contribute to the finalization of his thesis next year. Our dedicated efforts and extensive testing led to the development of a high-performing model, offering Mr. Boitel a wider range of options for his research. We delved into exploring alternative approaches, including evaluating OpenAI models, to overcome

15 CPGE: "Classes préparatoires aux grandes écoles", an intense two-year post baccalaureate undergraduate program that often leads to a School of Engineering in France.

complexities and limitations encountered along the way. These experiments proved valuable in advancing Mr. Boitel's thesis.

Overall, the progress achieved during our internship had a meaningful impact on Mr. Boitel's thesis. Our accomplishments in developing personalized models and exploring alternative approaches significantly expanded the research possibilities and enhanced the accuracy of sentiment analysis. The valuable insights gained from these efforts will undoubtedly contribute to the overall success of Mr. Boitel's research project.

4.3 Educational assessment

My journey throughout this internship has been remarkably eventful to say the least, considering that I began with close to no prior knowledge of machine learning. Over the course of two months, I dedicated myself to learning and absorbing as much informations as possible while providing assistance to Mr. Boitel in resolving the various challenges we encountered. I approached each day with an open mind, eager to delve into the depths of this fascinating field.

The challenges were numerous, but they proved to be invaluable opportunities for growth. From grappling with complex technical language to navigating unfamiliar algorithms, each obstacle pushed me beyond my comfort zone. The tasks I undertook demanded a level of expertise that I had to acquire from scratch. Additionally, I had the opportunity to use very recent technologies which were novel not only to me, but also to the researchers around me. It was a daunting experience, yet it enabled me to gain a profound understanding of the intricacies of machine learning.

This educational journey has been tremendously rewarding. Starting with minimal knowledge in machine learning, I have made substantial progress and acquired a range of skills that will definitely serve as a solid foundation for my continued studies and be a valuable asset as I venture into future projects.

Conclusion

In conclusion, my internship experience has been immensely valuable and has had a transformative impact on my professional development. Throughout the duration of the internship, I embarked on a challenging journey, starting with limited knowledge of machine learning and emerging with a solid foundation in this rapidly evolving field. Naturally, the sentiment analysis models project could not be concluded within the time frame of this internship, as it will be finalized by Mr. Boitel for his thesis next year. Nonetheless, we managed to make meaningful contributions and navigate complex challenges.

Looking back on this experience, I take great pride in the progress I have achieved and the significant contributions I have made to Mr. Boitel's research project. Beyond the technical knowledge gained, this internship has ignited within me a passion for research and a strong drive to pursue further opportunities in the field of machine learning. I am truly grateful to Mr. Boitel, Dr. Mohasseb, and Mrs. Couturier for granting me this invaluable opportunity.

As I conclude my internship report, I recognize that this journey has perfectly concluded my 2nd year of formation in the Big Data major of the IUT Nord Franche-Comté. The knowledge and skills acquired during this internship will undoubtedly serve as a valuable asset as I continue my studies and explore new projects in the field of artificial intelligence and predictive modeling. I am excited for next year and future projects, fueled by the experience and growth I have gained throughout this internship.

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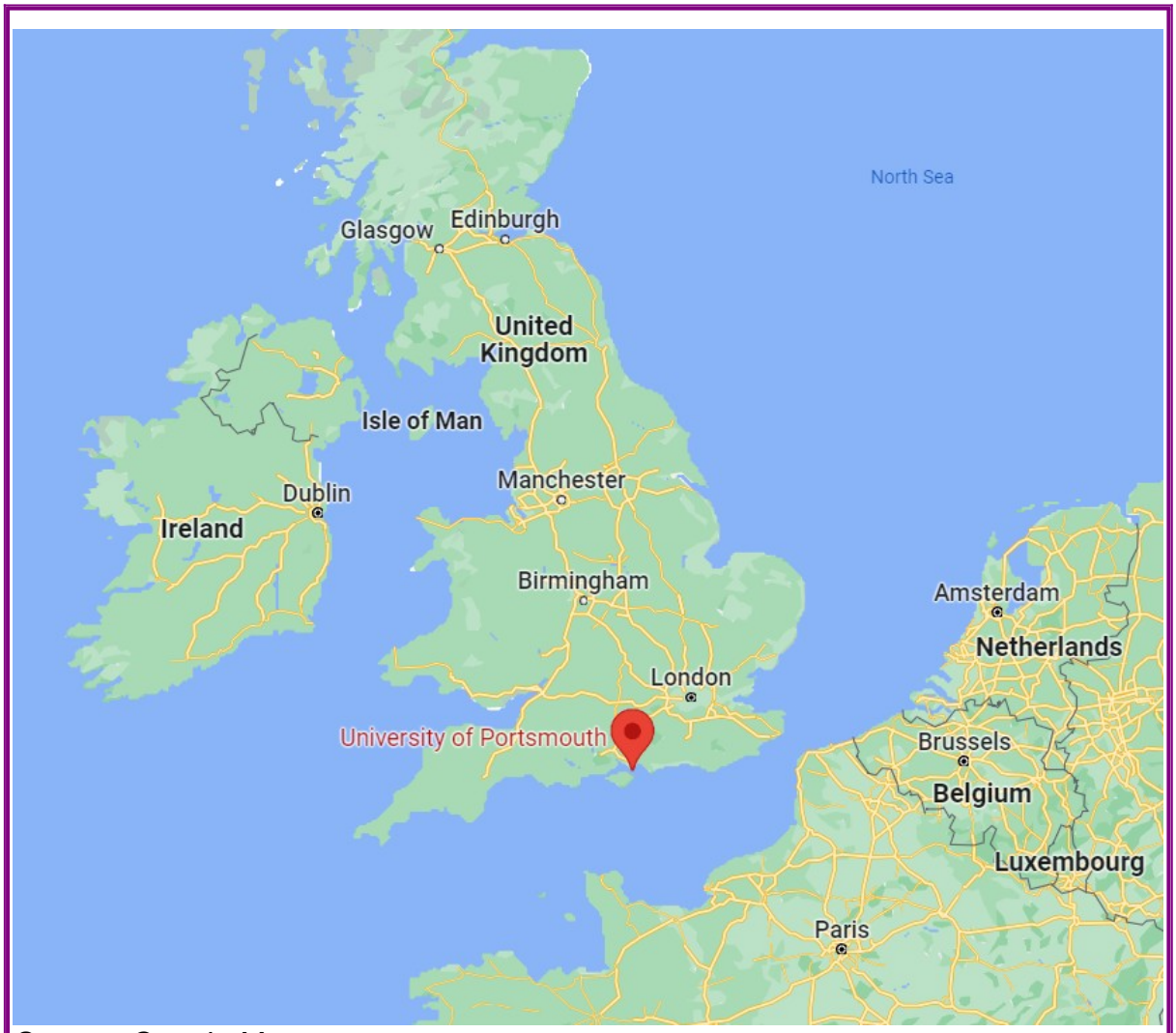
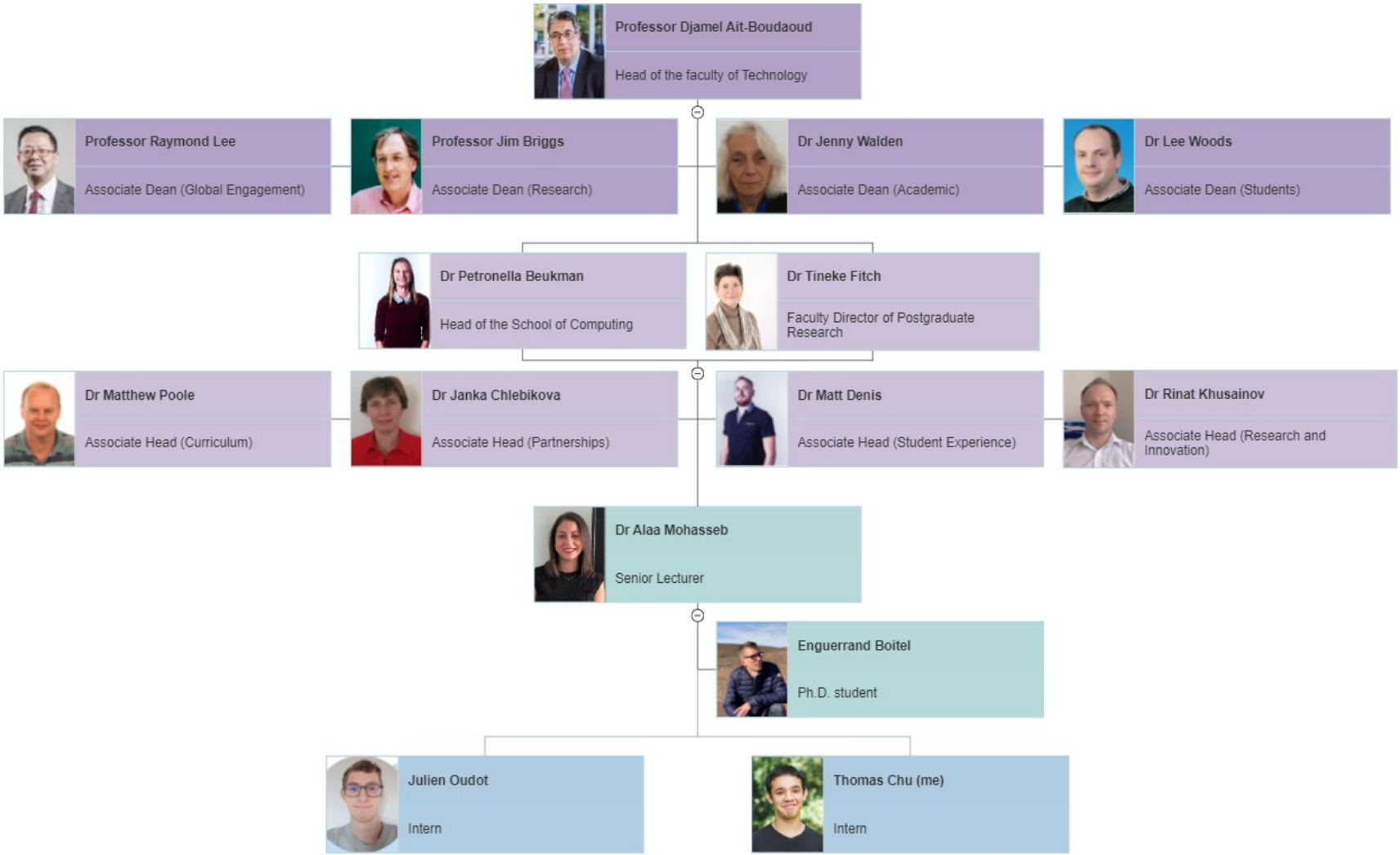
Annex I: Portsmouth University Location



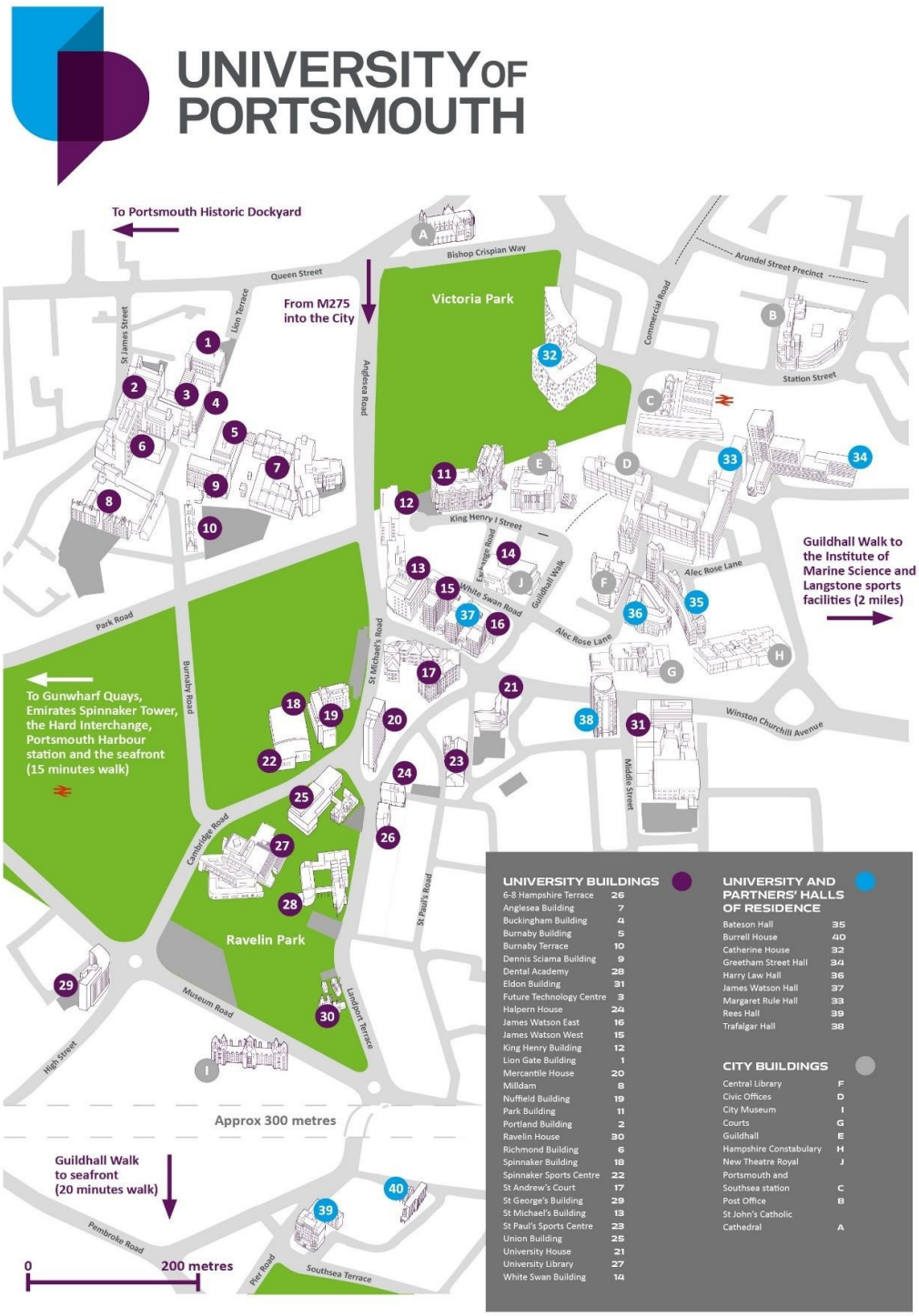
Source: Google Maps

Annex II: Organigram of the Faculty of Technology from the University of Portsmouth



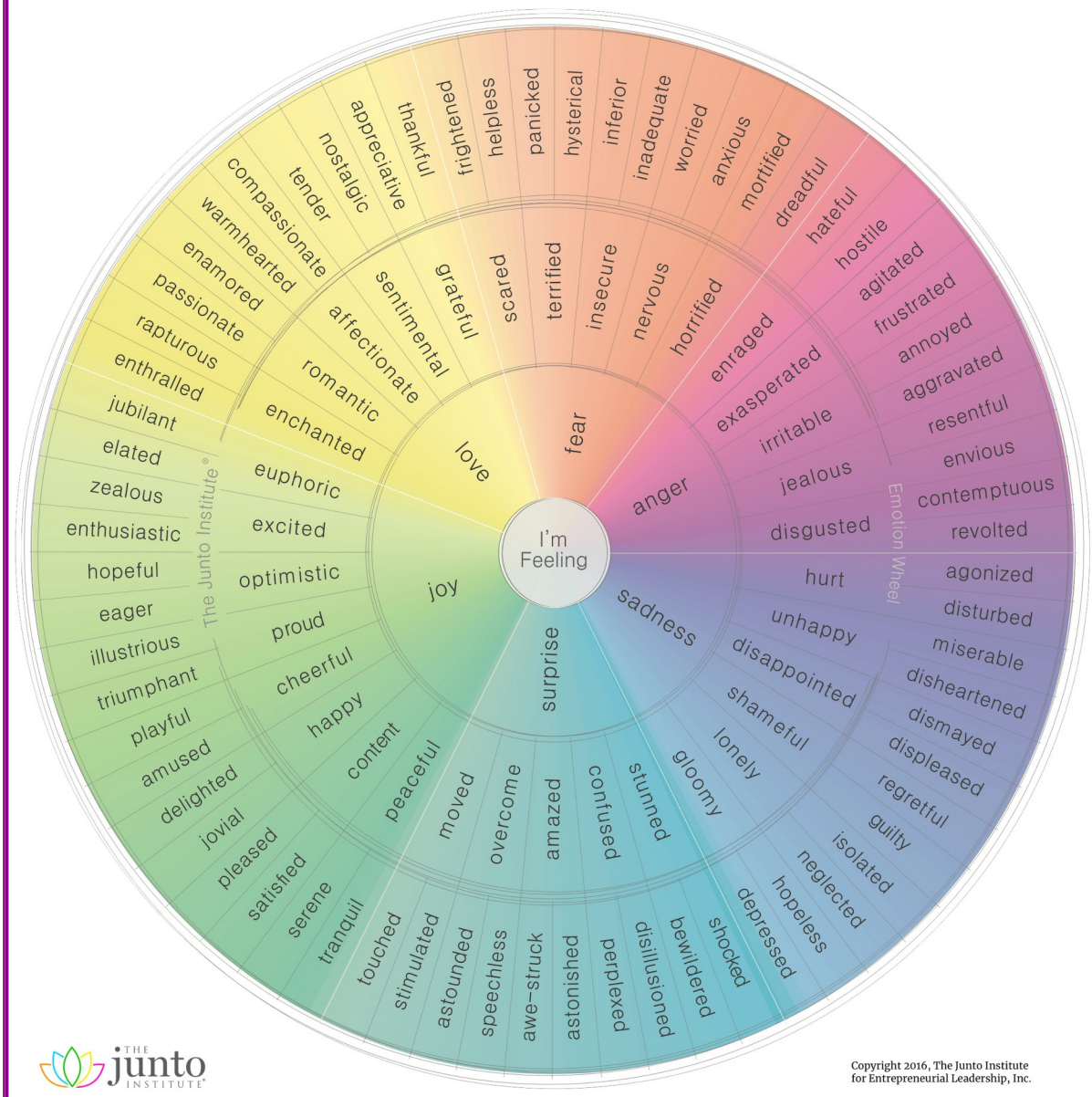
Source: University of Portsmouth website - https://www.port.ac.uk/

Annex III: Portsmouth University Campus



Source: University of Portsmouth website - https://www.port.ac.uk/

Annex IV: Emotion Wheel



Source: Emotion Wheel of the Junto Institute