Collecting and Implementing Ethical Guidelines for Emotion Recognition in an Educational Metaverse

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The metaverse represents a persistent, online 3D universe where people can interact, socialize, and work toward common goals. Education represents a key application domain, as it has the potential to enhance experiential learning and collaboration between learners and between learners and educators. However, challenges to the widespread adoption of educational metaverses persist. This paper focuses on *emotional isolation*, i.e., the feeling of emotional disconnection or loneliness, which can hinder learners' motivation and participation. Machine learning-enabled emotional recognition systems have the potential to address this challenge, offering educators with feedback on the emotional states of learners within the metaverse. Yet, the integration of emotion recognition systems raises ethical concerns regarding consent, privacy, and algorithmic bias. In this paper, we first conduct a literature review on the ethical considerations surrounding the deployment of emotion recognition technology within educational metaverses. Then, we report on the implementation of these guidelines within SENEM, an educational metaverse platform available in the literature. Through this research, we aim to contribute to the responsible deployment of emotion recognition technology in educational settings, ultimately fostering a supportive and inclusive learning environment for all learners.

CCS Concepts: • **General and reference** → **Surveys and overviews**; • **Software and its engineering** → **Software system structures**; • **Human-centered computing** → *Interaction design.*

Additional Key Words and Phrases: Facial Emotion Recognition; Ethical Guidelines; Educational Metaverse

ACM Reference Format:
Dario Di Dario, Viviana Pentangelo, Maria Immacolata Colella, Fabio Palomba, and Carmine Gravino. 2018. Collecting and Implementing Ethical Guidelines for Emotion Recognition in an Educational Metaverse. *ACM Comput. Surv.* 37, 4, Article 777 (August 2018), 9 pages. https://doi.org/XXXXXXX.XXXXXXX

1 INTRODUCTION

The metaverse, originally envisioned in Neal Stephenson's 1992 novel *"Snow Crash"* [27], has evolved into a tangible reality, stemming from the realms of Extended Reality (XR) and Virtual Reality (VR). It offers an immersive experience,

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described in contemporary literature as a three-dimensional virtual world where users freely explore and interact through customizable digital personas known as avatars [23]. Characterized by features such as persistent activities, experiential realism, interoperability, and scalability, the metaverse facilitates synchronous and real-time interactions among thousands, or even millions, of users simultaneously [9].

Among the multiple use cases of the metaverse, education represents a key application domain. On the one hand, the increasing diffusion of this technology has been favored by the COVID-19 pandemic [22], which enforced the identification of alternative means to let learners and educators interact. On the other hand, the innate immersive and interactive properties present new educational opportunities, transcending traditional constraints such as physical and language barriers, thus fostering a more equitable learning environment [18]. Indeed, the metaverse has the potential to facilitate experiential learning through immersive simulations and virtual experiments, enhances collaboration among students and educators, and supports personalized learning experiences tailored to individual student needs [18].

Nonetheless, all that glitters is not gold. Despite the many advantages offered by the use of metaverse for education, there are still open educational challenges that may limit the widespread diffusion of the technology. In the context of this paper, we focus on *emotional isolation*, that is, the feeling of disconnection or loneliness from others on an emotional level, which may negatively impact learners' motivation and participation [8].

Machine learning represents a potential instrument for identifying emotional isolation states within an educational metaverse: by analyzing patterns in user interactions and expressions, emotion recognition systems can detect signs of emotional isolation, enabling educators to intervene and provide necessary support to learners [8]. However, the introduction of these systems within an educational metaverse raises significant ethical challenges: indeed, the use of data collected from users' emotional expressions and interactions may present dilemmas regarding consent, privacy, and the potential for unintended consequences such as algorithmic bias or discrimination.

This paper proposes an initial step toward the deployment of ethical emotion recognition systems within an educational metaverse. We first provide a literature review of the ethical considerations surrounding the deployment of emotion recognition technology within educational metaverses. Building upon our findings, we report on our experience with the implementation of these ethical guidelines within SENEM [21], an existing educational metaverse platform available in literature. More particularly, we overview the steps already pursued and outline the future steps that will further enhance the integration of ethical guidelines into SENEM, ensuring its responsible and effective utilization within educational settings. By offering practical insights into the matter, we endeavor to pave the way for the responsible deployment of emotion recognition technology in educational metaverses, thereby enhancing the overall learning experience and fostering a supportive and inclusive educational environment for learners.

2 RELATED WORK

Stark et al. [26] and Hernandez et al. [13] both explore the challenges and ethical concerns surrounding the use of *Emotion Recognition Technology* (ERT) in Artificial intelligence (AI) systems. Stark et al. [26] critiques the reliance on psychological models in AI, arguing that these models fail to capture the full complexity of human emotions and overlook the ethical and social implications of interpreting emotional data. They advise for a comprehensive integration of ethical considerations in AI development, emphasizing the responsibility of professionals to consider the societal impacts of AI in emotional analysis.

Meanwhile, Hernandez et al. [13] discuss the technology's transition from expert-only use to broad commercial deployment, highlighting risks such as privacy violations and potential discrimination. The paper details the technology's applications across various sectors and underscores the lack of regulatory oversight that could lead to misuse. To

mitigate these risks, [13] proposes twelve guidelines centered on ethical practices, including informed consent and privacy, aiming to establish robust frameworks for the responsible deployment of emotion recognition technologies.

On top of these two works, Katirai [16] extensively analyzes the ethical dilemmas inherent in emotion recognition technologies, pinpointing three main ethical concerns: (1) potential biases stemming from flawed foundational methodologies in ERT, (2) the sensitive nature and possible misuse of emotional data, and (3) the considerable risks these technologies pose in critical societal sectors like education. The paper proposes specific guidelines to ensure that ERT is responsibly implemented in educational settings, focusing on fairness, privacy protection, and establishing clear, ethical boundaries to prevent exploitation and protect students' rights. This comprehensive review underscores the importance of ethical design and implementation practices prioritizing individual well-being and rights, particularly in education. It highlights the deep and potentially overwhelming ethical challenges presented by ERT and advocates for rigorous oversight to address these issues, especially in sensitive environments such as schools.

Multiple research studies have also explored the integration between ERT and the metaverse. However, these studies primarily focus on ERT and its technical aspects, such as increasing accuracy, real-time processing, and deep learning techniques, to deal with the complex task of recognizing and interpreting facial features and expressions.

Notably, recent research has made significant progress in facial emotion recognition. By incorporating hybrid features into a modular framework [1], these advancements have led to real-time applications such as eyeglass detection using transfer learning [15], face alignment [14], and depression detection through dual-stream multiple-instance learning from facial expression videos [25]. Moreover, geometric properties and statistical techniques have been studied to improve facial landmark detection [28]. Additionally, Gupta et al. [12] have developed a specialized convolutional neural network (CNN) to recognize human emotions from facial expressions in augmented and virtual realities.

Our work stands out from previous research in two significant ways. Firstly, while other studies have focused solely on the technical aspects of using ERT and the metaverse, we have taken the additional step of considering the ethical guidelines that must be in place for an immersive educational experience to be both engaging and effective. Secondly, we have gone beyond the algorithmic aspects of facial emotion recognition and integrated it into an open-source educational metaverse, planning future development to ensure critical ethical concerns. Our ultimate goal is to provide an ethical and fully realized educational environment that prioritizes facial emotion recognition. As a result, we advanced the state of the art by combining the ethical considerations for ERT with an open-source educational metaverse.

3 SENEM: A SOFTWARE ENGINEERING-ENABLED EDUCATIONAL METAVERSE

This section discusses the SENEM platform and its features [21], exploring its relevance to our work. Indeed, to achieve concrete results, we have leveraged this existing contribution to tangibly implement the literature review findings to enhance the educational metaverse. In particular, we extend this platform with a new feature able to implement emotion recognition that implements the ethical guidelines we have identified.

Pentangelo et al. [21] developed the Software Engineering-eNabled Educational Metaverse (SENEM), shown in Figure 1. The work represents a valuable advancement of the state of the art that links educational metaverse and software engineering due to the two main contributions obtained from the research. As a first contribution, the authors conducted an initial literature survey to identify the main elements to consider when creating a virtual educational environment. They then validated these requirements by consulting with experienced educators and learners, gaining valuable insights and perspectives on each requirement. Their work revealed that a substantial amount of literature focused on four primary macro-categories: (1) Virtual Environment, (2) Communication, (3) Avatar, and (4) Multimedia

Content. As a second contribution, they implemented the elicited requirements into a working prototype as shown in Figure 1—i.e., SENEM—which exhibits all the features identified in the first step of their research, and described below:

Virtual Environment. Users explore and interact with the platform in a 3D virtual environment resembling a real classroom. They can freely move in such an environment by walking with their avatar and interacting with different objects—e.g., chairs, a projector, a whiteboard—rotating the view and zooming in on components of interest. The system also allows the creation of simultaneous sessions protected by a password.

Communication Users can communicate with one another through different channels. They can use voice chat via a microphone or type messages into text chat. Moreover, they can perform non-verbal interactions through the emotes of their avatars—e.g., waving, raising a hand, or clapping.

Avatar Users can choose their representation in the metaverse through a customizable avatar. The platform presents an editor where users can choose the aspect of their avatar based on physical and personal characteristics, such as skin tone, hair, clothes, eyes, and more.

Multimedia Content The platform has a projector on which users can upload and share multimedia resources, supporting educational and collaborative activities. Moreover, users can write and share textual content with one another via an interactive whiteboard.

Fig. 1. The SENEM Metaverse.

Despite its potential, the SENEM platform is currently limited to primary functional requirements and lacks emotion recognition features. The metaverse's complexity allows for the integration of various technologies to enhance user immersion and engagement. This platform will enable us to implement our findings into SENEM by incorporating emotion detection and recognition, ensuring these enhancements align with established ethical guidelines.

4 COLLECTING AND IMPLEMENTING ETHICAL GUIDELINES FOR EMOTION RECOGNITION

The *goal* of the study was to combine emotional recognition technology with a unique use case in the metaverse: education. The *purpose* was to gain insight into managing sensitive information concerning the emotions of both learners and educators within a complex digital system like the metaverse. The study has a dual *perspective*: researchers

and practitioners. On the one hand, the former might be interested in using this information as a reference for future studies on privacy, inclusivity, and ethical user engagement in digital environments. The latter is keen to use the educational metaverse prototype to train educators on recognizing and responding to student emotions, even in a virtual setting. By doing so, the quality of interaction and learning outcomes will improve.

To obtain a comprehensive understanding of the ethical considerations encompassing emotional recognition technology, we performed a literature review. The entire process was driven by the following research question (RQ):

> ***RQ$_1$**: What ethical considerations and guidelines must be taken into account to ensure the secure deployment of emotional recognition technology in an educational metaverse?*

The objective of **RQ$_1$** is twofold. Firstly, it aims to gather current knowledge on ethical considerations related to emotional recognition. Secondly, the gathered information is used to enhance an already existing open-source platform for the educational metaverse, namely SENEM [21]. For clarity, Section 4.1 outlines the process for collecting papers through a literature review and presenting the obtained results. In contrast, Section 4.2 delves into the application in practice to include emotional recognition tasks in the SENEM platform, considering the ethical aspects identified.

4.1 Collecting Ethical Guidelines for Emotion Recognition

This section discusses the research method used to address **RQ$_1$**. Our focus is on describing the design and outcomes of the literature review conducted to identify the body of knowledge on ethical emotional recognition.

4.1.1 Design. In the context of our literature review, we followed a structured approach consisting of three primary steps. First and foremost, we created a research string derived from a set of carefully selected keywords to search for papers on ethical emotion recognition in an online digital library. Next, we collected and evaluated the knowledge obtained to ensure its relevance to our research objective. Finally, we extracted valuable insights to answer our research question. To ensure the completeness of our collection phase, we used well-established guidelines by Kitchenham et al. [17] and identified the main terms for our research based on our research question. To find an exhaustive list of terms, we focused on three specific domains retrieved from the research question: *emotional recognition*, *ethical guidelines*, and *education*. By exploring these domains, we identified a set of synonyms to broaden the scope of our research. Below is a list of the domains and the selected synonyms for each of them:

- **Emotional Recognition**: ("*emotional recognition*", "*emotional detection*", "*affective computing*")
- **Ethical Guidelines**: ("*ethics*", "*ethical*", "*ethical guidelines*", "*ethical considerations*")
- **Education**: ("*education*")

In formulating the query, the domains were isolated by applying the AND operator, while the synonyms of each domain were connected by employing the OR operator. The following box displays the general search string used in an online digital library.

> ***General Search String**: (("emotional recognition" OR "emotional detection" OR "affective computing") AND ("ethics" OR "ethical" OR "ethical guidelines" OR "ethical considerations") AND ("education"))*

To search for relevant literature, we ran the search string on *IEEE Xplore*[1], a well-known research engine. The output of this search consisted of 16 papers, out of which we selected four that focused on ethical emotional recognition. This approach helped us identify four most significant and informative research papers, which we then analyzed in-depth.

[1]https://ieeexplore.ieee.org/Xplore/home.jsp

To extract data, we used a *qualitative content analysis* technique [6], which involves carefully examining the relevant data to extract meaning and concepts. This process has two crucial phases: (1) iterative development of a codebook and (2) application of the codes to the raw data. In this study, the researchers who extracted the data also developed the codebook, while the primary author applied the codes to the raw text. The data was clear enough, so we did not use any additional software tools for this phase.

It is important to note that two experienced researcher authors constantly monitored and refined the entire process, meticulously reviewing all aspects, from the development of the research strings to the content analysis process. Their invaluable assistance ensured the resolution of any conflicts of data subjectivity.

4.1.2 Analysis of the Results. In the previous step, four articles were selected for content analysis. The analysis revealed a range of essential ethical guidelines for applying emotion recognition technologies in educational and research settings. These guidelines underscore the critical ethical considerations essential for employment emotion recognition, especially in the educational context.

When it comes to using emotion recognition technologies in educational and research settings, numerous ethical guidelines and considerations need to be taken into account. One of the most critical aspects of these guidelines is the **protection of privacy**, informed consent, and ethical compliance. Participants need to be properly informed and give their consent for their data to be used, and measures must be in place to ensure secure data management and protection of participant information [3, 4, 20, 24]. **Transparency**, **accountability**, and adherence to **legal and ethical standards** are also crucial, as are interdisciplinary ethical approval and robust data integrity measures [3, 20]. The guidelines also stress the importance of addressing **biases** and ensuring **fairness** and representation in the application of these technologies, promoting an inclusive and nondiscriminatory approach [20, 24]. Additionally, emotional safety, participant comfort, and potential **psychological impacts** of technology use must be managed properly, with a focus on mitigating negative emotional experiences and fostering a supportive and safe research environment [4, 20]. These guidelines advocate for a multidisciplinary approach to ethical issues, integrating insights from computer science and psychology to develop comprehensive standards that respect the self-respect and rights of all individuals involved [3].

4.2 Implementing Ethical Guidelines for Emotion Recognition

The first step for implementing facial emotion recognition is to use a well-structured dataset that contains face images. Canal et al. [5] already provides a literature review describing the most used and available datasets that can be used for emotion recognition. One of them is *Facial Expression Recognition 2013* (FER-2013) [11], composed of 35.887 images labeled in seven expressions: happiness, sadness, disgust, fear, surprise, and anger. We developed a Convolutional Neural Network (CNN) that can recognize emotions by analyzing grayscale images with dimensions of 48x48 pixels. The network architecture includes two convolutional layers, each with 32 and 64 filters and ReLU activations, for capturing visual features, followed by a max pooling layer to down-sample the image dimensions and dropout layers to prevent overfitting. After this first step, the model repeats this pattern with additional convolutional layers with 128 filters each to enhance detail detection. Finally, the network includes a flattened layer and two dense layers, with the final layer using softmax activation to classify images into one of seven emotion categories. To optimize learning, we used the Adam optimizer and categorical cross-entropy loss. The architecture of the network is schematized in Figure **??**.

It is worth noting that the model was initially pre-trained using a basic CNN through the Keras library, with data divided into 80% for training and 20% for testing. To optimize the model's settings, we employed Random Search, a method that helps find the best combination of parameters within the model by trying out various possibilities. The

model with the best combination of parameters was directly added to SENEM. We then take great care to ensure the most critical ethical concern identified by the literature: the protection of privacy. Indeed, the platform must respect user privacy and provide a safe environment for emotion analysis. Users are informed about why and how the emotion recognition feature is used. The information gathered is only for the teacher and does not affect students' grades. It helps the teacher adjust their teaching methods based on a general report of the class's emotions, which aims to make learning more effective. Users are informed that the webcam needs to be used to get real-time data about their facial expressions, but this data is not saved or stored to protect their privacy. Users can choose whether or not they want to use this facial recognition technology. If they decide not to use it, they can still attend the class, but their emotions will not be analyzed or shown to the teacher. Access to the SENEM platform does not require users to log in or register, which keeps their identities private. However, not knowing the exact identity of those who agreed to have their emotions analyzed or being unable to see each student's emotions might make the information less accurate. However, other aspects extracted from the literature review, such as transparency, bias and fairness, and psychological impacts, need more effort in future studies.

5 DISCUSSION AND FUTURE DIRECTION

To date, judiciously guiding the process of data management and preservation is of particular interest given the volumes of data collected and their extensive use in many applications, especially in the context of AI [2, 19]. For this reason, outlining ethical guidelines that can assist both participants and researchers in conducting experiments and scientific activities more clearly and safely is of crucial importance [2]. In this regard, a significant point of discussion is the discrepancy between the two most common types of guidelines proposed by research, namely purely theoretical guidelines and technical guidelines that support actual implementation activities. On the one hand, theoretical guidelines emphasize the importance of following a process that carefully adheres to ethical norms in tasks involving the collection of sensitive data, such as emotion recognition, ensuring these data are managed and stored transparently and securely; on the other hand, there is a need to complement them with actual technical guidelines that specify technologies and methodologies to make the former concretely implementable.

In the specific context of the metaverse, blockchain technology appears to be particularly promising in supporting researchers and developers in the challenge of concretely implementing an ethical, secure, and transparent process in collecting user data [30]. The blockchain is a distributed ledger technology that provides a secure and transparent record of transactions. It operates on a decentralized network consisting of a chain of digital records, where each record is linked to the previous one, forming a chain [30]. Blockchain technology has numerous applications in the metaverse, primarily related to the storing and exchanging data among users. For these reasons, the very nature of blockchain seems well-suited to the technical implementation of the ethical guidelines provided in our study [10, 29].

Given these motivations, a crucial future step in developing our work will be to complete and enhance the implementation of the ethical guidelines identified using specific technologies to support this task. A concrete example is provided by Di Dario et al. [7], who have constructed a comprehensive theoretical framework for including blockchain technologies in the metaverse. Leveraging this practical framework alongside ethical guidelines will lead to a complete, secure, and ethical process for collecting and analyzing user data for emotion detection, thereby enhancing the features of SENEM in this area in a significant and ethical-aware manner.

6 CONCLUSION

This study underscores the importance of ethical guidelines for emotion recognition technologies in educational metaverses. Through theoretical and practical exploration, we identified and applied key ethical considerations, including privacy, informed consent, and ethical compliance. These guidelines are essential for the responsible use of emotional recognition technologies, supporting educational outcomes while upholding ethical standards and user privacy. Our implementation of ethical guidelines in the SENEM platform has shown that it's feasible to improve emotion recognition technologies while respecting user privacy and promoting ethical interactions in digital educational environments. Additionally, the use of blockchain technology offers a promising research avenue to address ethical issues like data integrity and transparency in these complex digital ecosystems.

Continued research and development must stay vigilant about evolving ethical standards, and stakeholder needs to enhance the functionality of the educational metaverse and ensure it is inclusive, safe, and beneficial for all users.

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