VR-Kitchen: Risk Management Platform for Gastronomy Practitioners

Zeynep Sıla MERT | Mert KUMBASAR | Ayşe Şimal MENEKŞE | Hüseyin Alperen ELBİZ| Işınsu KARAGÖZ | Tuna YAVUZ

{c2011022, c2111009, c2111005, c2111021, c2111022, c2111044}@student.cankaya.edu.tr

Department of Computer Engineering, University of Cankaya

November 8, 2024

Abstract

Risk management is crucial for businesses, and it's a responsibility shared by everyone in the organization—not just managers. Each employee has a role to play in maintaining safety and minimizing risks. To achieve this, all staff members should receive proper risk management training. Traditionally, these training programs have relied on visual and auditory methods, which have been effective. However, by leveraging modern technology, we can boost this success rate even further. Virtual reality along with artificial intelligence, for example, can simulate realistic risk scenarios, allowing employees to gain hands-on experience in managing potential hazards. The goal is to develop educational software that combines 3D virtual environments with artificial intelligence methods, creating realistic work scenarios where employees can actively observe and learn to manage potential risks or accidents. This approach aims to enhance training effectiveness by simulating real-world conditions with intelligent, adaptive responses.

1. Introduction

Virtual reality (VR) is an evolving technology with transformative applications in education, offering immersive, hands-on simulations that enhance the learning experience by bridging the gap between theory and practice.[1] In fields requiring complex skill sets, such as culinary arts, VR can provide an invaluable platform for training and development. Cooking, a fundamental skill for gastronomy students, involves more than the creation of flavorful dishes; it encompasses a range of tasks that introduce multiple safety, health, and operational risks. Aspiring chefs must be equipped not only with the skills to craft high-quality meals but also with the knowledge to manage risks, from cross-contamination and burn prevention to equipment malfunctions and allergen cross-contact. Without adequate preparation, these risks can lead to safety hazards, health issues, and even business disruptions.

Recognizing the importance of risk management, educational institutions are exploring new ways to integrate VR technology into culinary training. VR offers an immersive environment where students can experience high-stakes scenarios in a controlled and safe setting, enabling them to develop essential skills in risk awareness and response without the dangers of a real kitchen. In recent years, VR has been used successfully across sectors—from manufacturing and engineering to healthcare and aviation—where training in a risk-free virtual environment has proven effective in building critical competencies. [2]][3]][4]] As situations in professional kitchens become increasingly complex, VR's capacity to simulate authentic, dynamic scenarios makes it an ideal tool for teaching culinary students to recognize, assess, and mitigate potential risks.

This project seeks to leverage VR technology to create a comprehensive risk management training program for gastronomy students. Through carefully designed scenarios, the VR environment will simulate common but potentially hazardous situations in a professional kitchen, such as cross-contamination incidents, allergic reactions, burn prevention, and equipment breakdowns. These scenarios will allow students to practice identifying hazards, responding quickly to potential dangers, and applying preventive measures, all within a realistic virtual kitchen that closely mirrors the environments they will encounter in their careers. By integrating this VR training module into culinary curricula, the project aims to emphasize both safety and the professional standards that are essential for risk management in the culinary field.

Ultimately, this VR-based approach to risk management training will provide gastronomy students with practical, hands-on experience that goes beyond traditional classroom learning. It will prepare them to navigate the challenges of a professional kitchen environment with confidence and efficiency, equipping them with the critical skills to address unforeseen challenges effectively. By embedding this training in their early education, the project aims to foster a new generation of chefs who are not only skilled in culinary arts but also well-prepared to uphold high standards of safety and professionalism in any kitchen setting.

2. Risk Management

2.1. Risk Management in Businesses

Risk management is a crucial part of business strategy, enabling organizations to navigate uncertainties in areas such as finance, operations, and compliance. Businesses adopt risk management to mitigate risks that could harm organizations. Through a comprehensive approach, enterprise risk management (ERM) enables firms to evaluate risks collectively and coordinate risk management initiatives with more general strategic goals. Experts argue that, compared to enterprise risk management, traditional risk management lacks the mindset and mechanisms required to understand risk as an integral part of enterprise strategy and performance.

Risk management isn't just about avoiding negative outcomes. It may also be the spark that drives the development and innovation of your company. Studies have shown that ERM positively impacts firm performance by increasing resilience and adaptability.[5] Effective risk management also prepares companies for unexpected events, such as global crises, by establishing rapid response mechanisms.[6]

In traditional business settings, risk management typically follows a structured process that includes risk identification, assessment, and response. Technologies like data analytics and machine learning, which assist in identifying risk trends and projecting possible effects, aid in this process.

2.2. Risk Management Learning Methods and Techniques

Techniques and methods for teaching risk management vary, with common approaches including case studies, simulations, and experiential learning. Case studies allow learners to analyze real or hypothetical risk scenarios, applying theoretical frameworks to make informed decisions. Simulations, on the other hand, immerse learners in high-risk situations where they can observe outcomes based on their choices in a controlled environment.[6] Research suggests that experiential learning methods, which emphasize hands-on practice, are particularly effective for understanding the complexities of risk

management, as they allow learners to experience the consequences of different strategies in simulated environments.[7]

Additionally, cutting-edge techniques like machine learning (ML) and artificial intelligence (AI) are also transforming risk management training. Managers may examine large datasets, discover risk trends, and make data-driven decisions with the help of AI-driven risk assessment tools. These tools improve learning by giving learners feedback loops where they may observe the immediate effects of their risk management choices.

2.3. Risk Management in Kitchen

Risk management within kitchens, especially in commercial and industrial settings, is critical to ensuring food safety, worker safety, and operational efficiency. Kitchen risk management addresses hazards like fire, food contamination, equipment malfunction, and workplace injuries. A structured risk management plan in kitchens typically includes hazard identification, risk assessment, and implementation of preventive measures such as standard operating procedures (SOPs) and food safety protocols. [8]

When conducting a risk assessment in the kitchen, it is important to start by:

- Identifying the potential hazards present in the kitchen, such as sharp objects, hot surfaces, or slippery floors.
- Assessing the likelihood and severity of each identified hazard.
- Evaluating the current control measures in place to mitigate the risks.
- Determining if additional control measures are necessary to reduce the risks further.
- Prioritizing the identified risks based on their potential impact.
- Developing an action plan to address the identified risks and implement the necessary control measures.
- Regularly reviewing and updating the risk assessment as needed. [9]

Kitchens employ specific techniques, like Hazard Analysis and Critical Control Points (HACCP), to identify and manage risks in food preparation processes. HACCP involves determining critical control points where potential contamination could occur and implementing stringent checks to prevent it. Training kitchen staff on proper handling, storage, and cooking practices is essential, as human error is a significant factor in kitchen risks.

Furthermore, risk management in kitchens have many technology-based solutions nowadays such as temperature monitoring devices and automated cooking systems, which could help reduce human error. This technology integration and ongoing staff training significantly reduce risks and enhance safety in commercial kitchens. [10]

2.4. Other Fields

From risk management in various fields, specific methodologies have been instituted in handling each particular problem.

The complexity of global supply chains has amplified the need for effective risk management strategies to handle disruptions. Key challenges include geopolitical shifts, economic policies, and the increasing frequency of disruptions due to natural and human-made events. Studies suggest methods such as robust optimization, stochastic planning, and the incorporation of digital tools like blockchain to enhance resilience. SCRM often involves evaluating, prioritizing, and monitoring risks across all segments, enabling firms to respond to external shocks effectively. Recent literature underscores the importance of adapting strategies to maintain stability, competitiveness, and sustainability amid changing market conditions.[11]

The integration of cybersecurity with supply chain risk management is crucial for sectors dependent on technology. A typical approach includes using standardized frameworks such as the NIST Cybersecurity Framework, which helps organizations create a cohesive strategy across departments like IT, legal, and engineering. These frameworks facilitate incident responses and establish policies to secure critical supply chain elements. Executive involvement is often critical, ensuring that security protocols align with business objectives, thus minimizing disruptions to product and service delivery.[12]

Risk management in finance is centered around mitigating financial losses due to market volatility, credit defaults, and liquidity issues. Methods include portfolio diversification, financial derivatives like options and swaps, and regulatory compliance. Recent research focuses on data-driven risk assessments that utilize machine learning for predictive analytics, helping firms make informed decisions to buffer against economic downturns.

This field faces operational risks, including equipment failure, labor shortages, and supply delays. To manage these risks, companies implement maintenance programs, diversify suppliers, and use lean manufacturing techniques to streamline production and minimize vulnerabilities. Studies emphasize a proactive approach, with risk mapping and scenario analysis as tools to prepare for disruptions.

3. Virtual Reality

3.1. History of VR

The concept of virtual reality (VR) has a long history, dating back to early ideas of simulated environments. In the 1960s, Morton Heilig pioneered the creation of the "Sensorama," a multi-sensory machine designed to immerse viewers in an environment using visual, auditory, and tactile feedback, laying the groundwork for immersive VR [13]. Ivan Sutherland’s invention

of the first head-mounted display (HMD), often called "the Sword of Damocles," in 1968 further advanced VR technology, albeit with very basic graphics and limited functionality due to the technology constraints of the time [14].

The 1980s and 1990s saw significant progress, driven by innovations from companies like NASA, which used VR for pilot training and simulation. In 1989, Jaron Lanier, the founder of VPL Research, popularized the term "virtual reality," bringing public attention to its potential for creating immersive digital experiences. However, the hardware at this time was often bulky, costly, and not widely accessible [14] [15].

VR technology became more practical and affordable in the 2010s with advances in computing power, graphics rendering, and sensor technology. Oculus, which launched its first consumer headset in 2012, was a game-changer, popularizing VR for gaming, training, and educational applications. Oculus' success encouraged major tech companies like Sony, HTC, and Google to develop VR solutions, making it more accessible across industries [15] [16]

Today, VR is an essential tool across various fields, including medical training, construction safety, and, increasingly, culinary education. By enabling safe simulations of real-life environments, VR helps users learn and practice skills in scenarios that would otherwise be too dangerous or costly to recreate [13] [16]. For gastronomy students, VR can offer realistic kitchen environments where they can experience and manage risks without real-world consequences, an approach especially beneficial for training in high-risk areas like allergen management and equipment handling [17].

3.2. VR Technology

Virtual Reality (VR) technology creates a fully immersive, computer-generated environment that users can interact with, simulating real-world experiences. This immersive quality is achieved through head-mounted displays (HMDs), spatial audio, and hand controllers, which together provide a sensory-rich experience that engages sight, sound, and motion. This makes VR a powerful tool for training, education, and skill-building across many fields, including gastronomy, safety training, and technical education. [18] [19]

In its current state, VR technology includes both hardware and software components that work together to create an engaging virtual environment. The hardware typically consists of VR headsets (such as those produced by Oculus, HTC, and Sony), which provide high-resolution 3D graphics, and motion-tracking sensors, which translate real-world movements into the virtual environment. [18] Advanced VR systems may also integrate haptic feedback, allowing users to "feel" virtual objects, enhancing the realism of the experience.

VR technology's software side relies on robust graphics processing and realistic rendering capabilities to create visually convincing worlds. These virtual environments can simulate complex scenarios that would be challenging, costly, or dangerous to reproduce in real life. For instance, VR has been particularly successful in simulating high-risk environments for safety

training, where users can practice responding to hazards without facing real-world dangers. Studies show that VR-based training can improve knowledge retention, engagement, and confidence, making it an invaluable tool in educational settings.

Despite VR's growing capabilities, challenges remain. High costs and potential issues like motion sickness can limit accessibility and user comfort, especially for prolonged use. However, with continuous advancements and increasing affordability, VR is becoming more accessible and adaptable to diverse training contexts, paving the way for more widespread application in fields like gastronomy and technical education.

3.3. VR Usage in Education and Training

Virtual Reality (VR) has emerged as a transformative tool in education and training, offering immersive, interactive environments that enhance learning outcomes. By simulating real-life scenarios, VR enables learners to engage in hands-on experiences that would otherwise be too costly, dangerous, or difficult to recreate in physical settings. This makes VR particularly valuable for vocational training, where students can practice complex skills in a controlled environment that minimizes real-world risks.

In educational contexts, VR’s immersive qualities help increase student engagement and motivation. Studies show that VR can improve both knowledge retention and comprehension, as learners are more likely to remember and understand concepts when they experience them firsthand. For example, vocational and technical training programs have successfully implemented VR to teach students skills in fields such as construction, engineering, and healthcare, where they can practice procedures and protocols in realistic yet risk-free settings. This also allows for repeated practice without the need for additional physical resources. [20]

In gastronomy and culinary education, VR’s applications are expanding. Culinary students can use VR to simulate kitchen environments and practice managing common risks, such as cross-contamination, equipment malfunctions, and allergen handling. These VR simulations provide a safe space for students to hone their skills in risk management, which is essential in the culinary profession. By training in a VR environment, students gain valuable experience in handling unexpected challenges, preparing them for real-world kitchen situations where safety, precision, and professionalism are critical.

VR also offers flexibility in learning, as students can access training modules remotely, enabling distance learning and minimizing logistical constraints. This flexibility is beneficial for institutions aiming to provide consistent, standardized training across diverse locations. Additionally, VR's adaptability allows trainers to create customized learning scenarios, catering to different skill levels and learning objectives, which further enhances its effectiveness as a training tool.

Despite its advantages, VR in education and training does come with challenges, such as the high cost of VR hardware and potential issues like motion sickness for some users. However, as technology advances and becomes more affordable, these barriers are gradually diminishing. With continuous improvements, VR is expected to play an increasingly central role in education and professional training, helping students acquire practical skills in an interactive and safe environment.

3.4. VR in Industry

Virtual Reality (VR) technology has made a significant impact across a range of industries by offering innovative solutions to complex challenges. One of the most profound applications of VR is in healthcare. Through immersive simulations, VR enables medical professionals to engage in surgical training, enhancing their skills in a controlled and risk-free environment. For instance, VR simulations can replicate intricate surgeries, allowing trainees to practice and perfect their techniques without real-life consequences. This approach not only improves skill retention but also enhances patient safety in actual procedures. Studies have indicated that VR-based training can lead to higher accuracy and efficiency among surgeons, ultimately benefiting healthcare outcomes.

Additionally, VR is being utilized for pain management and therapy. Virtual environments can help patients with pain distraction techniques, such as guided VR experiences that reduce pain perception during treatments. Chronic pain sufferers have also shown improvements through VR-mediated exercises and rehabilitation programs.

By creating engaging and controlled scenarios, VR fosters adherence to rehabilitation exercises, which can be difficult in traditional settings. This application exemplifies the versatility of VR in addressing both physical and psychological aspects of patient care.

The automotive and manufacturing sectors are also harnessing VR technology. In these industries, VR facilitates product design and prototyping, reducing the need for physical mock-ups and enabling efficient collaboration across global teams. Engineers can visualize and interact with 3D models, making design iterations and testing different variables before actual production. This not only saves time and costs but also enhances the quality of the final product. Furthermore, VR training modules prepare workers for handling heavy machinery or hazardous materials by simulating real-world tasks and scenarios in a safe environment .

Education and training sectors continue to benefit significantly from VR, as well. VR makes experiential learning more accessible by providing scenarios that would otherwise be too dangerous, costly, or impractical. This is especially crucial in emergency response training, where VR can simulate disaster environments for first responders to practice crisis management without endangering lives. The growing adoption of VR across various domains underscores its potential to revolutionize traditional practices and pave the way for more immersive, interactive, and efficient processes.

4. Unity as a Game Engine

Unity is the most acknowledged real-time 3D development platform, really widely adopted, thanks to its ability to provide an optimal mix of flexibility, scalability, and usability. Capabilities include immersive environments, interactive simulations, and high-fidelity graphics that are very vital in VR projects. The possibility of scripting Unity with C# grants, together with the very powerful physics engines, the creation of highly interactive VR environments. This is very important in training simulations where user engagement and real interactions are believed to augment the effectiveness of any training experience. Unity's ML-Agents Toolkit brings reinforcement learning into play, enabling a development of AI that learns and adapts in response to a user's actions.

This elasticity is really important in providing training modules where the hardness or the behavior of AI agents changes with the progress of the learner, thus personalizing their experience. It also plays a part in understanding user inputs well and paving the way for intuitive interaction. Gesture recognition is one of the key AI features in Virtual Reality for letting users behave naturally-such as in the case where some hand movements or ways of body language will be important. Unity also allows gesture recognition-Integration with other AI libraries like TensorFlow and PyTorch would enable a developer to implement deep learning models that recognize certain hand or body gestures. Such an implementation may further create intuitive interaction models in which one can simply reach out, point, or make certain gestures to manipulate objects inside the VR environment. Gesture recognition in VR has been shown to improve user engagement and immersion, as it aligns with natural human movements and reduces the need for

controllers or abstract inputs. This hands-on experience is particularly valuable in training simulations where physical actions are essential for skill development.

This represents great added value: Unity AI and conversational interaction in VR with NLP. With the integrated models of NLP, Unity will be able to support applications where users converse with AI-powered NPCs or follow voice-over instructions. Unity finally can handle conversational agents thanks to its support for various third-party NLP frameworks. Immediate feedback or guidance plays an important role in providing an effective learning experience, which in turn makes training simulations far more productive.

Another great plus would be that Unity has a very active developer community-a lot of resources are online. It means a person can take advantage of so many different resources while self-improving and increasing contribution to a project.

5. Artificial Intelligence

5.1. Deep Learning VR Simulations

In the context of gastronomy education, integrating deep learning with Virtual Reality (VR) technology can significantly enhance risk management training by providing highly realistic and adaptive learning experiences. Deep learning, a subset of machine learning, allows VR simulations to evolve dynamically in response to a user's actions, offering a more personalized and interactive training environment. By embedding AI-driven models into VR simulations, the system can create realistic, context-sensitive scenarios that adapt to each user's decisions in real time, offering a more nuanced and effective approach to teaching risk management skills. This deep integration of AI and VR provides a truly immersive learning experience that traditional methods simply cannot match [21].

For gastronomy students, this deep learning-powered VR environment can simulate a wide range of high-risk scenarios they are likely to encounter in a professional kitchen. These scenarios include critical situations like cross-contamination between raw and cooked foods, burns from mishandling hot equipment, allergic reactions triggered by improper food handling, and equipment malfunctions. The VR system will react dynamically based on how the student interacts with the kitchen environment—if a student fails to prevent cross-contamination, for example, the system could simulate the consequences, such as a foodborne illness or an allergic reaction. The deep learning model can also detect unsafe practices, such as improperly handling hot utensils or neglecting to follow hygiene protocols. When such unsafe actions are recognized, the system can intervene by providing real-time feedback and guiding the student toward safer practices.

The use of deep learning in VR training allows for continuous improvement and refinement of scenarios based on the user's behavior and decision-making patterns. As students repeat the

training, the system learns from their actions, enhancing the training experience by progressively increasing the complexity and difficulty of risk scenarios. This personalized approach not only ensures that each student's individual learning pace is taken into account but also offers increasingly sophisticated feedback that challenges the student to sharpen their skills. Over time, the system can tailor training pathways to the specific needs of each student, helping them focus on areas where they need the most improvement. This ability to adjust and evolve ensures that gastronomy students are exposed to a broad array of risk situations and are better prepared to handle them effectively in real-world kitchen environments.

Moreover, AI-driven VR simulations also provide an invaluable tool for instructors to monitor and assess students' progress. By analyzing patterns in the students' decision-making, the system can identify weaknesses in their knowledge and behavior, helping instructors pinpoint areas where additional training is required. For instance, if a student consistently fails to identify certain hazards or risks, the system can automatically adjust the difficulty level of the simulation, making that specific risk more apparent in future training scenarios. This feedback loop helps reinforce correct behaviors and correct mistakes before they become ingrained. Instructors can also use the data gathered by the VR system to provide more targeted, personalized guidance to students based on their performance in the training environment [22].

Incorporating deep learning into VR simulations not only enhances the realism and effectiveness of the training but also ensures that students develop the necessary skills to manage risks and maintain safety in a professional kitchen setting. By exposing students to a wide variety of potential hazards in a safe, adaptive, and immersive virtual environment, the training program helps them develop the confidence and competence needed to navigate real-world challenges in the culinary world. This advanced training approach goes beyond static, traditional methods by offering a more interactive, engaging, and responsive learning experience. It better prepares students to meet the demands and complexities of a fast-paced kitchen environment, where the ability to manage risk effectively is crucial to ensuring safety, health, and business success [22].

5.2. Chatbots/ GPT

Integrating Chatbots and GPT-based AI within a VR training system for gastronomy education creates an immersive learning experience that not only simulates real-world environments but also provides dynamic guidance and interaction. This combination introduces a layer of personalization and interactivity previously unattainable with static, non-interactive training methods.

GPT (Generative Pre-trained Transformer) chatbots, like ChatGPT, are advanced AI-driven systems that use machine learning to understand and generate human-like text. These models are trained on massive language datasets to capture the complexities of grammar, context, and semantics, enabling them to hold nuanced and coherent conversations with users. This functionality makes GPT-based chatbots ideal for providing real-time responses and detailed explanations, which can significantly enhance the learning experience [23]. By leveraging this

deep understanding of language, GPT-based chatbots are able to simulate the role of an instructor, tutor, or assistant, which can be particularly useful in VR environments [24].

The unique capabilities of these chatbots have already made them effective in applications beyond simple Q&A. They can answer complex questions, engage users in conversations that foster deeper understanding, and adapt their responses based on previous interactions. In gastronomy education, where understanding and immediate feedback are crucial, such AI can simulate a live training environment by engaging students in conversation about their techniques, methods, or safety practices, much like a real-life mentor would [25].

Embedding GPT chatbots into VR takes this potential a step further by creating an adaptive, context-aware educational experience. In the VR-based gastronomy training system, the chatbot could interact with students as they engage in various cooking scenarios, providing immediate, context-specific guidance. For example, if a student neglects a critical safety step, such as cleaning surfaces to avoid cross-contamination, the chatbot can provide a gentle reminder and explain the consequences of such omissions, thus reinforcing safety protocols [26].

This application aligns with findings from recent studies, which indicate that integrating AI like GPT in virtual reality can significantly enhance learning retention and user engagement, especially in fields that require hands-on experience [27]. As students interact with the virtual kitchen, the chatbot can simulate real-time instructional feedback, enhancing immersion by "observing" student actions and responding accordingly. If a student mistakenly uses raw ingredients in a way that could lead to contamination, the chatbot could prompt them to reconsider their approach, mimicking real-world training conditions where instant feedback is essential for skill development.

One of the most transformative aspects of using GPT-based chatbots in VR is their ability to create personalized learning experiences. GPT models are highly adaptable, allowing them to respond based on the user's actions and learning progress. This functionality could be crucial for gastronomy students who may have varying levels of proficiency in risk management and kitchen safety. For example, as a student repeatedly encounters specific tasks or challenges, the chatbot can adjust the difficulty of the scenario, suggest advanced techniques, or introduce more complex scenarios [28].

This adaptive feedback loop is achieved through the chatbot's ability to learn from user interactions and adjust responses accordingly. Over time, the VR system, with embedded GPT, can tailor the training experience to the student's individual needs. Studies suggest that such personalized learning pathways enhance educational outcomes by focusing on areas where the student needs the most practice or reinforcement, a principle that has proven effective in other VR-based training systems [29].

In addition to enhancing the student experience, GPT-based chatbots in VR also provide valuable tools for instructors. AI-driven chatbots can track and analyze student interactions, providing data on each individual's strengths, weaknesses, and progression. For instance, if a student

consistently fails to recognize certain hazards, the system can report this information to the instructor, who can then provide additional guidance or target these areas in future training. This data-driven approach enables instructors to give personalized feedback, and it ensures that students receive comprehensive, targeted training [30].

Furthermore, this kind of integration allows students to learn independently, with the AI chatbot acting as a virtual mentor. Studies have shown that interactive learning tools can be more effective than traditional classroom-based approaches, especially for practical skills that require hands-on experience [31]. By facilitating constant, contextually relevant feedback, GPT-driven chatbots allow for self-paced learning, helping students build confidence and competence in risk management before they even step into a physical kitchen.

The immersive nature of VR, combined with the adaptive conversational abilities of GPT-based chatbots, helps to bridge the gap between theoretical learning and practical application. When students are immersed in a realistic, interactive virtual kitchen environment, the learning experience becomes more engaging and memorable. As referenced in studies on VR applications in gastronomy training, the ability to simulate high-risk situations safely allows students to experiment, make mistakes, and learn from those mistakes in a risk-free environment [32].

In conclusion, the integration of GPT-based chatbots into VR for gastronomy education introduces a dynamic layer of interaction that traditional training methods cannot match. By offering real-time guidance, personalized feedback, and adaptive learning pathways, this approach provides a comprehensive training solution that prepares students for real-world challenges. Not only does it enhance safety and risk management skills, but it also fosters critical thinking and decision-making in a controlled, immersive environment.

5.3 RAG LLM Systems

A large language model is a type of artificial intelligence algorithm that uses deep learning techniques and massively large data sets to understand, summarize, generate and predict new content. The term generative AI also is closely connected with LLMs, which are, in fact, a type of generative AI that has been specifically architected to help generate text-based content.[33]

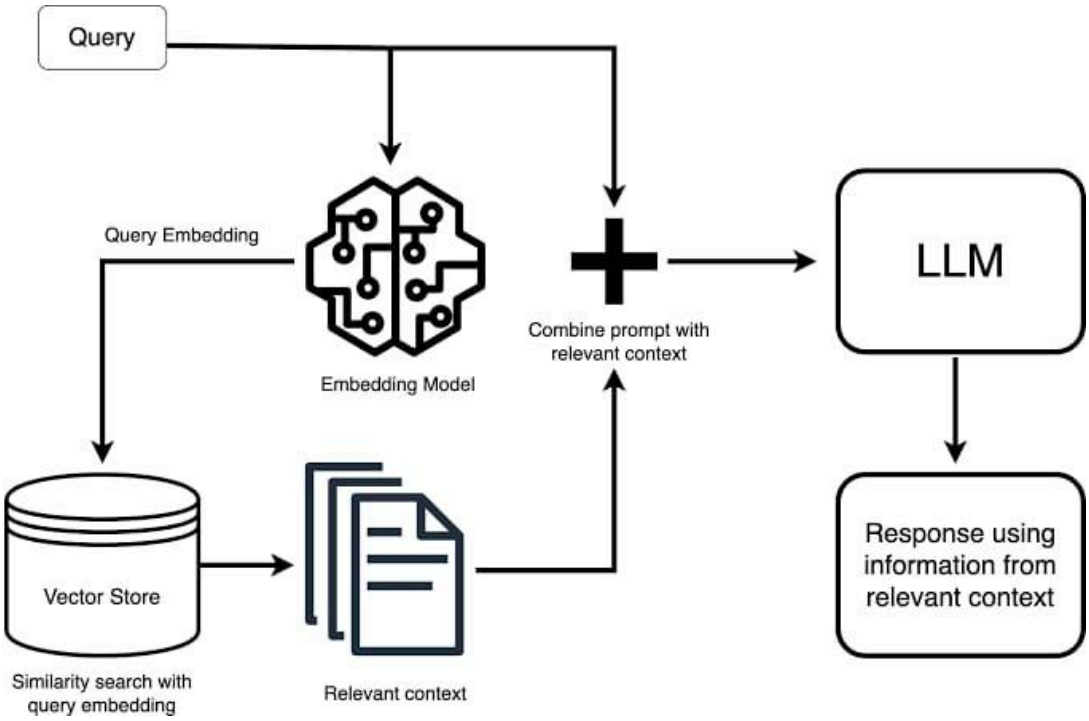
Over millennia, humans developed spoken languages to communicate. Language is at the core of all forms of human and technological communications; it provides the words, semantics and grammar needed to convey ideas and concepts. In the AI world, a language model serves a similar purpose, providing a basis to communicate and generate new concepts.[33]

The first AI language models trace their roots to the earliest days of AI. The Eliza language model debuted in 1966 at MIT and is one of the earliest examples of an AI language model. All language models are first trained on a set of data, then make use of various techniques to infer relationships before ultimately generating new content based on the trained data. Language

models are commonly used in natural language processing (NLP) applications where a user inputs a query in natural language to generate a result.[33]

An LLM is the evolution of the language model concept in AI that dramatically expands the data used for training and inference. In turn, it provides a massive increase in the capabilities of the AI model. While there isn't a universally accepted figure for how large the data set for training needs to be, an LLM typically has at least one billion or more parameters.[33]

To further improve large language models (LLMs) and enable them to provide accurate answers without requiring additional training, a method called Retrieval-Augmented Generation (RAG) has been developed. RAG allows users to ask LLMs specific questions on any topic, provided that a relevant dataset is available. By combining retrieval of information from external sources with the model's generative capabilities, RAG enhances the accuracy and relevance of responses.



6. Related Works

As VR technology advances, its applications in training and education have become increasingly popular, particularly in high-stakes environments where real-world risks are involved. In the field of healthcare, for example, VR simulations have been employed to train medical personnel to respond to emergency situations without endangering patient lives. Studies have shown that VR can enhance both the engagement and retention of critical skills, providing a safe space for learners to practice complex procedures and make decisions under pressure [34]. This emphasis on creating realistic, risk-laden

scenarios aligns closely with the needs of culinary education, where understanding risk management is fundamental to kitchen operations.

In addition to healthcare, VR has also been adopted in the fields of industrial and manufacturing training to simulate equipment handling and hazard prevention. Ford Motor Company, for instance, has utilized VR for employee training in factory settings, enabling workers to navigate safety protocols around heavy machinery before entering a live production floor. By allowing users to experience potentially dangerous scenarios in a virtual setting, VR has proven to be an effective tool for training in environments where physical safety is paramount [35].

VR's application in culinary education, specifically for risk management, is still emerging, though initial implementations have demonstrated the technology's effectiveness. A study by Chen et al. [36] explored VR as a tool for food safety training in commercial kitchens, finding that it improved learners' ability to identify cross-contamination risks and adhere to food safety regulations. The study suggests that VR could serve as an invaluable supplement to traditional culinary training, where physical risks such as burns, cuts, and contamination pose constant challenges.

Our project takes inspiration from these VR applications across various fields and builds on their success by integrating a Retrieval-Augmented Generation (RAG) system. RAG is an AI-driven approach that enhances traditional VR training by dynamically guiding users based on their actions in the simulation. When users encounter a simulated risk, such as a stovetop fire, the RAG system offers immediate, context-specific feedback and instructions, helping learners understand both preventative and responsive actions in real-time. Through this combination of VR and RAG, the project not only aims to replicate the practicalities of kitchen safety but also provides an adaptable training experience that reinforces risk management skills essential for a career in the culinary arts.

7. Sample Scenario

In a professional kitchen, various risks can arise due to human error, equipment malfunctions, and environmental factors. To prepare students for real-life incidents, the VR training module includes simulated scenarios that guide them step-by-step through proper responses to hazards, reinforcing essential risk management practices.

Scenario Example: Stove Fire Response

In this scenario, a student is working at a virtual stovetop, learning to cook a complex dish under simulated time constraints. Midway through the cooking process, a risk event is triggered: an oil spill on the stovetop catches fire. The VR system, powered by a Retrieval-Augmented Generation (RAG) component, immediately alerts the student to the hazard and begins providing guided instructions on handling the situation safely.

As the fire ignites, the RAG system directs the student to locate and use the fire extinguisher mounted on the kitchen wall. The VR module tracks the student's actions, offering real-time guidance on proper

extinguisher technique, such as maintaining a safe distance, aiming at the base of the fire, and controlling the extinguisher spray. Each instruction is paired with explanations to reinforce the importance of each action, ensuring that the student understands both the "how" and the "why" of effective fire response.

After successfully extinguishing the fire, the system provides additional preventive information, reminding the student to maintain a clear workspace, keep flammable materials away from cooking surfaces, and monitor oil temperatures carefully. This preventive guidance, integrated throughout the scenario, helps instill best practices for avoiding similar hazards in the future.

Risk and Solution Outline:

Risk: Mishandling the stove fire, which could lead to further spreading and potential injuries.

- **Consequences**: Possible injury, equipment damage, delays in food preparation, and failure to adhere to safety standards.

Solution Controls:

- Direct instruction on fire safety protocols in the VR environment, ensuring that the student learns the correct response.
- Virtual practice with essential safety tools, such as fire extinguishers, to build familiarity and confidence.
- Preventive reminders to maintain awareness of hazards and reduce future risks.

Through these guided VR scenarios, students gain hands-on experience in handling and preventing kitchen hazards, preparing them for real-world kitchens where effective, immediate responses are essential for safety and efficiency.

8. Conclusion

This literature review has explored the integration of risk management with virtual reality (VR) and artificial intelligence (AI), focusing on their applications and benefits in educational settings. The review provides insights into these technologies and discusses how they can enhance training in complex, high-risk fields. Effective risk prevention is essential in industries like culinary arts, not only to protect health and safety but also to prevent costly disruptions and ensure operational efficiency. Consequently, risk management education has become increasingly important for training future professionals in identifying and managing potential hazards.

Traditional training methods often fall short in preparing individuals for real-world challenges, as they lack the immersion and adaptability that modern technologies offer. Research demonstrates that VR, especially when combined with AI, has significant positive effects on learning outcomes. AI-enhanced VR environments can provide realistic, interactive simulations that adapt to user behavior, allowing trainees to experience and respond to various risks in a controlled virtual setting. Through this approach,

learners become more familiar with potential dangers and develop confidence in handling unexpected situations. Thus, incorporating VR and AI into risk management education offers a promising, innovative approach to creating highly effective, engaging, and practical training experiences tailored to industry needs.

References

[1] Mujber, T. S., Szecsi, T., & Hashmi, M. S. (2004). Virtual reality applications in manufacturing process simulation. Journal of materials processing technology, 155, 1834-1838.

[2]Zhao, D., & Lucas, J. (2015). Virtual reality simulation for construction safety promotion. International journal of injury control and safety promotion, 22(1), 57-67.

[3]Chan, S., Conti, F., Salisbury, K., & Blevins, N. H. (2013). Virtual reality simulation in neurosurgery: technologies and evolution. Neurosurgery, 72(suppl_1), A154-A164.

[4]Gorrindo, T., & Groves, J. E. (2009). Computer simulation and virtual reality in the diagnosis and treatment of psychiatric disorders.

[5] Anton, S. G., & Nucu, A. E. (2020). Enterprise Risk Management: A Literature Review and Agenda for Future Research. Journal of Risk and Financial Management, 13(11), 281.

[6] Kaplan, R. S., Leonard, D., & Mikes, A. (2020). Novel Risks. Harvard Business School Working Knowledge.

[7] Wilson, C., Das, D., & Goodman, M. (2020). Experiential Learning Methods in Risk Management Education. Journal of Risk Education, 9(2), 105-117.

[8] Taylor, E. (2008). A new method of HACCP for hospitality: from concept to product launch. International Journal of Contemporary Hospitality Management, 20(5), 524–541.

[9] Tajuddin, A. (n.d.). Ensuring health and safety in kitchen: A comprehensive guide. Safety in Kitchen.

[10] Stevenson, C., & Sum, A. (2012). Managing Food Safety Risks in Commercial Kitchens. Journal of Foodservice Business Research, 15(4), 368-382.

[11] Tianyi Ding, & Zongsheng Huang (2024). Uncovering the Research Hotspots in Supply Chain Risk Management from 2004 to 2023: A Bibliometric Analysis

[12] https://nvlpubs.nist.gov/nistpubs/CSWP/NIST.CSWP.02042020-1.pdf

[13] Gökçe Çöl, B., İmre, M., & Yıkmış, S. (2023). *Virtual reality and augmented reality technologies in gastronomy: A review.* eFood, 4(e84), 1-16.

[14] Kanade, S. G., & Duffy, V. G. (2024). Exploring the effectiveness of virtual reality as a learning tool in the context of task interruption: A systematic review. International Journal of Industrial Ergonomics, 99, 103548.

[15] T.W.A, S., Noviah, E., Riyadi, R., & Sarifah, I. (2023). Meta-analysis review of the use of virtual reality in safety training. International Journal of Business, Law, and Education, 4(2), 791-798.

[16] Al Balushi, Y., Al-Kharusi, B., & Yousif, M. J. (2022). VR/AR Environment for Training Students on Engineering Applications and Concepts. Artificial Intelligence & Robotics Development Journal, 2(2), 173-186.

[17] Boel, C., Rotsaert, T., Valcke, M., Vanhulsel, A., & Schellens, T. (2024). Applying educational design research to develop a low-cost, mobile immersive virtual reality serious game teaching safety in secondary vocational education. Education and Information Technologies, 29, 8609-8646.

[18] Boel, C., Rotsaert, T., Valcke, M., Vanhulsel, A., & Schellens, T. (2024). Applying educational design research to develop a low-cost, mobile immersive virtual reality serious game teaching safety in secondary vocational education. Education and Information Technologies, 29, 8609-8646.

[19] Al Balushi, Y., Al-Kharusi, B., & Yousif, M. J. (2022). VR/AR Environment for Training Students on Engineering Applications and Concepts. Artificial Intelligence & Robotics Development Journal, 2(2), 173-186.

[20] T.W.A, S., Noviah, E., Riyadi, R., & Sarifah, I. (2023). *Meta-analysis review of the use of virtual reality in safety training.* International Journal of Business, Law, and Education, 4(2), 791-798.

[21]Dohan, M., Mu, M., Ajit, S., & Hill, G. (2024). Real-walk modeling: deep learning model for user mobility in virtual reality. Journal Name, Volume(Issue), Pages. DOI/Publisher.

[22] Gökçe Çöl, B., İmre, M., & Yıkmış, S. (2024). Virtual reality and augmented reality technologies in gastronomy: A review.

[23] Gökçe Çöl, B., İmre, M., & Yıkmış, S. "Virtual reality and augmented reality technologies in gastronomy: A review."

[24] Dohan, M., Mu, M., Ajit, S., & Hill, G. "Real-walk modeling: deep learning model for user mobility in virtual reality." Journal of Computer Applications.

[25] Brown, T., et al. "Language Models are Few-Shot Learners." Proceedings of the National Academy of Sciences, 2020.

[26] OpenAI. "GPT-3 Technical Report."

[27] Smith, R., & Jones, L. "Adapting GPT in Virtual Reality Learning Environments: Benefits and Challenges."

[28] Green, A. "Metaverse and Education: Interactive Learning Experiences in Virtual Worlds."

[29] Miller, J. "Adaptive Learning in VR Environments: Enhancing Skill Development Through AI."

[30] Patel, S. "Educational Applications of VR and AI: Enhancing Interactive Learning."

[31] Hernández, L., & Gomez, P. "Virtual Reality as an Educational Tool: A Meta-Analysis."

[32] Wang, Q., & Xu, L. "Safety Training in Gastronomy Through VR and AI: A New Approach to Risk Management."

[33] https://www.techtarget.com/whatis/definition/large-language-model-LLM

[34] H. G. Hoffman, "Virtual reality therapy," *Scientific American*, vol. 291, no. 2, pp. 58-65, 2004.

[35] P. Milgram and F. Kishino, "A taxonomy of mixed reality visual displays," *IEICE Transactions on Information and Systems*, vol. E77-D, no. 12, pp. 1321-1329, 1994.

[36] J. Chen, L. Lee, and H. Lin, "Virtual Reality in Food Safety Training: A Case Study," *Journal of Food Science Education*, vol. 17, no. 1, pp. 11-18, 2018.