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Usefulness, Ease-of-use, and Acceptance towards Generative AI in Language Learning of Non-Language Majors: A TAM-based Study

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***Abstract*—** *This study offers to investigate non-language major college students' perceptions concerning Generative Artificial Intelligence (GAI) in terms of its usefulness, ease of use, and acceptance in language learning through a questionnaire survey grounded in the Technology Acceptance Model (TAM). A total of 213 engineering college students participated in the study who are in international programs. The findings of the study indicated that the majority of the respondents highlighted a positive perception towards and acceptance of GAI in language learning. Specifically, 60.09% of the students strongly agree that GAI helps them complete tasks faster and also believe that performance is more effective and productive. In addition, in terms of ease of use in GAI language learning, students strongly agree with ease of use, believing that their interaction with GAI is clear and easy to understand, with an overall average of 51.96%. The results also revealed that non-language majors would recommend the use of GAI in language learning (55.87%), that students have accepted the use of GAI to the extent of using it every day, and are resolved to continue the use of GAI in learning languages.*

I. INTRODUCTION

In our daily lives, utilizing other individuals' languages is vital. An increasing number of individuals are starting to focus on second language acquisition to enhance their communication abilities, as exemplified by Hedman and Magnusson (2022) in Sweden, who suggested fortifying students' multilingual learning capabilities to better adapt to the progression of globalization. In the field of language learning, English is the lingua franca of academics and dominates the global language (Rose et al., 2022), which makes more and more non-native English-speaking countries request the choice of English as a second language to learn. In one survey, Afghan undergraduates not only generally showed a more positive attitude towards learning English (Orfan & van de Weijer, 2020), but also showed the versatility of English and its important value in education. Therefore, learning English as a second language is a reasonable option for non-native English-speaking countries from a more international perspective.

With the development trend of globalization and the requirement of a second language, studying abroad has become the training direction of most international colleges, which allows students to learn about the local culture and improve their language skills (Cullinan et al., 2022). This training direction makes the students at the International Engineering College (IEC) different from ordinary undergraduates in terms of English learning requirements, especially in the aspect of courses. The English courses for ordinary undergraduates mainly focus on the training of English topics, which is more inclined to the examination aspect, while the IEC students mainly focus on the individualization and all-round development of English ability, from listening, speaking, reading, and writing, which are more conducive to students studying abroad.

Such higher requirements mean that IEC students need more effective methods to solve learning problems in English.

OpenAI's launch of ChatGPT at the end of 2022 represented a significant advance for the technology in the field of text generation, while 2023 became a pivotal year, often considered a breakthrough period for generative artificial intelligence (GAI). Technically, GAI refers to artificial intelligence systems capable of producing human-like outputs, such as text, images, and conversational interactions. The development of generative artificial intelligence (GAI) has generated great interest and discussion in various fields, including education, which has also reasonably become the tool that some IEC students choose to use in English learning. In addition, with the improvement and progress of science and technology, the field of Artificial Intelligence in Education (AIED) has developed significantly in the past 25 years (Roll & Wylie, 2016), where GAI has a huge advantage in language processing. Unlike traditional language learning tools, which typically rely on pre-programmed content and exercises, GAI is an unsupervised or partially supervised machine learning framework that uses statistics and probability to generate outputs (Grassini, 2023). In addition, GAI uses generative modeling and deep learning (DL) to produce a variety of content at scale from existing media such as text, graphics, audio, and video (Jovanovic & Campbell, 2022). This ability opens up new possibilities for engaging in immersive learning experiences, enabling students to interact with AI instructors, practice conversational skills, and receive immediate feedback. Specifically, the wide variety of advantages demonstrated by GAI include the ability to reduce time and increase the speed of learning, provide learners with a personalized learning experience, and introduce them to other cultures (De La Vall & Araya, 2023). Additionally, GAI demonstrates numerous potential applications within the realm of education and learning, functioning as a versatile tool that can serve as a learning aid, writing aid, and research aid (Liu et al., 2023). As Oke et al. (2023) point out, GAI has been shown to be beneficial in foreign language classrooms because of its strong content generation capabilities and its reasonable use. Specifically, by utilizing AI tools, students can read course material repeatedly until they reach a deeper level of understanding. This repetition ensures that students can grasp and understand the content even without direct guidance from the teacher. Concurrently, for the acquisition of foreign language speaking skills, the integration of AI-based voice recognition technology (speech learning systems) with conversational learning systems has been shown to provide significant support (Oke et al., 2023). In some instances, students exhibit greater flexibility in their use of Generative Artificial Intelligence (GAI), as their application of GAI extends to various aspects of language learning. In group discussions on language learning, students sometimes use artificial intelligence tools to generate answers related to target vocabulary, making them more efficient in discussions with peers (Fer et al., 2024). In a classroom setting, generative artificial intelligence (GAI) can also be applied to tasks such as language translation, paragraph generation, and essay writing. According to a study conducted by Johnston et al. (2024) involving students from the University of Liverpool, many of the surveyed students reported utilizing GAI for proofreading, answering foundational knowledge questions, enhancing their writing skills and vocabulary, and learning grammar. In a similar study conducted by Yang et al. (2023) with Engineering students at a university on their dependence on translation software in learning languages, they somehow model their use of similar technological support in language learning. These examples illustrate the diverse purposes and applications of GAI by students. GAI, through its language interaction capabilities, greatly facilitates the language learning process for students.

However, according to Chen et al. (2020), there was a lack of studies that both employed AI technologies and engaged deeply with educational theories. Moreover, despite the enormous potential of GAI for language learning, there has been very limited research on the potential impact of emerging technologies such as artificial intelligence (AI) on the education of non-English major international students and surveys of their inclusion and acceptance by university students (Wang et al., 2023). Relevant research needs to be further carried out, which also gives the future research direction of language learning in the information age.

Therefore, this study aims to understand non-language major college students' views on the usefulness, ease of use, and acceptance of generative AI in language learning through a questionnaire survey based on the Technology Acceptance Model (TAM), which considers perceived usefulness and ease of use as key determinants of technology acceptance. This paper attempts to explore the students' attitudes towards integrating GAI into the language learning experience.

II. LITERATURE REVIEW

In recent years, the field of language education has undergone significant changes due to advances in artificial intelligence (AI) technology (Shahid et al., 2023). In the past two years, there has been a large amount of literature on the optimization of artificial intelligence and language

learning. Understanding past and present research on GAI, as well as related models, helps to better understand the impact of current GAI on the field of language learning. Further, referring to past research on the utility, ease of use, and acceptance of AI can be referential and useful for investigating the current attitudes of non-language majors towards GAI, since GAI technology has changed so fast.

2.1 GAI (Generative AI)

Dwivedi et al. (2021) highlighted that artificial intelligence (AI) has the potential to greatly revolutionize several industrial, cognitive, and societal domains by improving and maybe replacing various human skills and functions. The OpenAI Chatbot (ChatGPT), unveiled to the public in November 2022, stands as a paragon of Generative Artificial Intelligence (GAI). "Generative" refers to a system that can create a new text based on the input it receives (Mondal et al., 2023). Its inception marked a watershed moment in the realm of natural language processing, captivating users worldwide with its unparalleled ability to engage in meaningful, human-like conversations. Because of the capacity GAI has, it has emerged as a promising tool in language learning, especially by offering innovative approaches to teaching and enhancing proficiency in second languages. Chatbots are an illustration of a macro- and micro- level AI (Artificial Intelligence) application utilized in the classroom or even outside to assist students in developing their speaking, reading, writing, and listening skills, among other language-related talents (Gayed et al., 2022).

However, GAI's bottom-level logic for generating dialogue and text is based on machine learning, which determines the bias and inaccuracy of the content it produces. Especially in the field of language learning, which is related to cultural communication, exposing learners to biased information content without discrimination can be devastating. According to Mondal et al. (2023), using GAI in schools could create misleading or factually incorrect information. It could result in students being misled or even denied their education.

This uncertainty is caused by two key factors: the continual development and immaturity of Generative Artificial Intelligence (GAI) technology, as well as insufficient information screening. As a result, GAI may not always provide the most accurate information. Rather than focusing solely on technological advancements, this study focuses on the second reason: users' biases, particularly among language learners, regarding GAI adoption and the importance of cultivating a balanced perspective towards this emerging technology in order to maximize its benefits. Given that GAI's widespread adoption is very new, with only a year since its global ubiquity, there is still a scarcity of research on this topic.

2.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a theoretical framework used to explain and predict how users will accept and utilize a new technology. Based on the Theory of Reasoned Action (TRA), this model was initially proposed by Davis in 1989 and is designed to understand the factors that influence users' adoption of information technology (Davis, 1989). The TAM originated from psychological theories of rational action and planned behavior and has since evolved into a key model for understanding the predictors of human behavior to forecast potential acceptance or rejection of technology (Marangunić & Granić, 2014).

With the increasing use of artificial intelligence, theories adopted by various technologies were used to explain the acceptance of these products. Sohn and Kwon (2020) believe that when using innovative and less valuable products, such as intellectual products based on artificial intelligence, attention to technology touches more than the practical aspect.

In recent years, with the emergence of large language models such as ChatGPT, more and more students have tried to use GAI to study a new language, so it is necessary to pay attention to the acceptance and practicability of using GAI for language learning. In addition, it is essential to continually explore new directions for the future development of GAI language learning and how to refine it for better application in the language learning process. By integrating TAM with GAI, it is important to investigate the most suitable path for GAI development that optimizes the user experience.

2.3 Perceived Usefulness

GAI is unquestionable when it comes to practicality. GAI can help users with language learning in different ways, but at the same time, there are certain limitations. The results of a survey show that about 60% of users believe that GAI can help them improve their writing skills, and most learners believe that GAI can improve their English-speaking skills. At the same time, there is also a large proportion of users who believe that GAI is not conducive to increasing their vocabulary (Ayesha et al., 2023). This study effectively shows that the usefulness of GAI can only be manifested in some aspects, that there may still be shortcomings in other aspects, and that relying solely on GAI is clearly not desirable. At the same time, the usefulness of GAI can be demonstrated not only in language learning but also in daily life. Some GAI users have mentioned that GAI can provide inspiration for their daily lives, such as cooking tips or shopping options. In these respects, GAI has always been

able to demonstrate rationality and creativity. Also, there are even a few people who are willing to consider GAI as a friend (Blanka et al., 2024). These examples show the usefulness of GAI in daily life, and it can be seen that the usefulness of GAI exists in different aspects.

2.4 Perceived Ease-of-use

GAI is generally easy to use. The ease-of-use of GAI can be reflected in different ways. A study showed that users of GAI showed a very satisfied attitude towards GAI compared to the tools they had previously used. Compared to traditional search engines and user forums, GAI users believe that GAI is more capable of collecting information (Blanka et al., 2024). Most people are already quite proficient in using traditional search engines. This shows that GAI is easy to use, which is a valid example of GAI showing its ease-of-use. Likewise, other studies have mentioned that GAI has an overall positive perception of language learning in terms of perceived ease of use and attitudes (Blanka & Seraj, 2023).

2.5 Perceived Acceptance

Different people have different opinions about the acceptance of GAI. A small number of people have low acceptance of GAI, mainly because of niche issues such as browser compatibility issues. However, among those who have low acceptance of GAI, the vast majority of them are first and foremost because of integrity issues. The use of GAI for cheating is a serious problem (Blanka et al., 2024). In the past, a large proportion of the assignments in the teaching process were required to be completed independently. But now, because of the widespread use of GAI, some students use GAI to complete their homework. Most schools will consider this to be deceptive and ban it. In this case, the acceptance of GAI will be lower. Second, convenience is mainly related to ethical and technical issues. One study showed that, 99% of AI chatbots have only been able to answer simple questions. Especially when it comes to some ethical and accuracy issues, it needs to be used with caution (Gutiérrez, 2023). It can also be seen that the development of GAI is still at an imperfect stage and requires further research and development. This is one of the main reasons why some people have low acceptance of GAI. In addition, it is assumed that the ethical and technical issues of GAI will not be discussed for the time being. GAI is a handy tool in many other areas, both in our daily lives and in many other areas, such as education, healthcare, science, and information and communication technology (Blanka et al., 2024). As a result, a large percentage of the population has a high acceptance of GAI. Acceptance of GAI has been mixed, mainly due to personal factors, technical limitations, and ethical factors. This also shows the limitations of GAI.

Overall, the relevant research (Klimova and Pikhart, 2022; Klimova et al., 2023) highlights the positive effects of GAI on language learning, while GAI is also misleading and limited when used in schools (Mondal et al., 2023). In addition, previous literature (Chang et al., 2017) has shown that experienced students tend to have a more positive perception of ease of use, which provides a reliable basis for guessing that non-language majors, especially those with basic knowledge of electronics and computers, are more likely to use GAI tools like Chat-GPT. However, it can be found that the existing research lacks a reliable investigation of the attitude of non-language majors towards using GAI tools in language learning. Therefore, on the basis of the above literature, this study further embarks on a specific perceptual journey, using the Technology Acceptance Model (TAM) for assessment and prediction. This paper focuses on exploring the usefulness, ease of use, and acceptance attitude of non-language majors towards GAI. Meanwhile, research on how to integrate TAM and GAI to enable students to obtain the optimal language learning approach still needs to be explored in the future.

III. METHODOLOGY

3.1 Research Design

The implemented design of the current study was descriptive-quantitative design. The present investigation aimed to investigate the usefulness, ease-of-use, and acceptance towards Generative AI in language learning of non-language learners. Relative to this, studies, such as this, aiming to quantify variables is a quantitative type of investigation (Kothari, 2004). Moreover, it is descriptive due to the employment of simple statistics (limited to mean [M] and standard deviation [SD]) to characterize the mentioned variables (Torres et al., 2021).

Additionally, data gathering was performed through the use of survey questionnaires noted as a classic technique suggesting that collection was performed in a relatively short period of time. On another note, in the investigation no establishment of controlled nor experimental group was done connoting that the study is non-experimental (Torres & Alieto, 2019). The research sample of the study constituted a total of 213 non-language learners of International Engineering College.

3.2 Research Tool and Procedure

To quantify the perception toward GAI in language learning of the respondents an adapted research tool was utilized based on Technology Acceptance Model. In total, the questionnaire consisted 18 items equally divided among the aspects with a Cronbach's alpha score of 0.89. Moreover, the items are answerable with a four-point Likert scale

(ranging from strongly disagree to strongly agree). The items were adapted and modified to suit the context of the present study which focus on non-language learners; thus, the instrument was pilot tested to 30 students who did not form part of the final sampling size. The instrument yielded a reliability score of Cronbach's alpha equals 0.89. The research tools after validation and pilot testing were finalized and digitized via wjx.cn form and the link was distributed using Wechat as the popular used social media. This option was made noted to be practical and wise. Respondents were initially identified and communicated and responses were received in due time for the analysis of the data.

IV. RESULTS AND DISCUSSION

1. What is the perceived usefulness of GAI in language learning?

Usefulness	Strongly Agree (SA)	Agree (A)	Disagree (D)	Strongly Disagree (SD)	Mean
1. Using GAI in the class activities helps me accomplish tasks more quickly.	128 (60.09%)	76 (35.68%)	7 (3.29%)	2 (0.94%)	1.45
2. Using GAI improves my class performance.	120 (56.34%)	76 (35.68%)	13 (6.1%)	4 (1.88%)	1.54
3. Using GAI increases my class productivity.	127 (59.62%)	75 (35.21%)	9 (4.23%)	2 (0.94%)	1.46
4. Using GAI enhances my effectiveness in class.	125 (58.69%)	74 (34.74%)	12 (5.63%)	2 (0.94%)	1.49
5. Using GAI makes it easier to do my homework.	126 (59.15%)	68 (31.92%)	15 (7.04%)	4 (1.88%)	1.52
6. GAI is useful as a student.	135 (63.38%)	70 (32.86%)	7 (3.29%)	1 (0.47%)	1.41
Total	761 (59.55%)	439 (34.35%)	63 (4.93%)	15 (1.17%)	1.48

Through six items, the results in Table 1 show that the GAI is seen favorably in language learning. More than 55% of respondents strongly agreed with each statement, and over 90% of respondents agreed with each question. Notably, 60.09% of respondents strongly agreed that they complete tasks faster when using GAI in class activities. In contrast, 3.29% of students disagree, and only 0.94% of the respondents strongly disagree. Additionally, 56.34% of students strongly agreed that using GAI improves their class performance, and 35.68% of students agreed with that. Similarly, 59.62% of respondents agreed that using GAI increases class productivity, but there are more students who disagree with this statement than the other statements, which reach a 7.04 percentage, and 1.88% of them strongly disagree GAI will help in doing homework. When it comes to GAI's overall benefits to the respondents, 63.38% of them strongly agree. One respondent strongly disagreed with the statement, while seven disagreed and seven agreed, out of the 213 total.

This suggests a high conviction in the value of GAI for learning new languages. When it comes to getting things done, interestingly, over 95% agree that GAI enables them to complete tasks quicker. This shows that students believe that using GAI is valuable to them to be more time-efficient in their workload. Similarly, 92.02% mention that the use of GAI enhances their class performance as well. In their judgement, GAI is undoubtedly a teaching aid that can improve the language abilities of students and enhance communication skills, skills that are prerequisites for educational success.

Although the data does not explicitly measure ease of use, the high levels of agreement and strong agreement (over 55% strongly agreeing to each question) imply that students find GAI intuitive and user-friendly. If the technology were difficult to use, it is unlikely that it would receive such positive feedback. Voss et al. (2023) noted that assistive technologies, such as generative artificial intelligence tools, are now more widely available and are being used extensively in second language classroom teaching and learning. The ease of use is a vital factor because it directly affects how frequently and effectively students can utilize GAI in their studies.

The overall acceptance of GAI is further underscored by the finding that roughly one hundred percent of students consider GAI beneficial to them as a whole. Liu et al. (2024) point out that since late 2022, a variety of powerful generative AI technologies have emerged, which may empower L2 (second language) learners to engage in informal language learning with greater creativity and versatility by using the technology acceptance model (TAM) and collecting a total of 867 Chinese English learners' respondents via an adapted TAM online questionnaire and inviting 20 to attend the post-survey interviews. This overwhelmingly positive reaction implies that students consider GAI as more than just a supplement; they see it as an essential part of their learning process. Furthermore, 94.83% of respondents reported that GAI boosts student productivity in the classroom, implying that it promotes a more productive learning environment.

2. What is the perceived ease-of-use of GAI in language learning?

Ease-of-use	**Strongly Agree (SA)**	**Agree (A)**	**Disagree (D)**	**Strongly Disagree (SD)**	**Mean**
1. Learning to use the GAI has been easy for me.	113 (53.05%)	81 (38.03%)	17 (7.98%)	2 (0.94%)	3.43
2. I find it easy to get the GAI to do what I want to do.	109 (51.17%)	83 (38.97%)	18 (8.45%)	3 (1.41%)	3.4
3. My interaction with the GAI is clear and understandable.	107 (50.23%)	84 (39.44%)	20 (9.39%)	2 (0.94%)	3.39
4. I find the GAI to be flexible in interacting with.	113 (53.05%)	77 (36.15%)	22 (10.33%)	1 (0.47%)	3.42
5. It is easy for me to become skilled at using the GAI.	107 (50.23%)	83 (38.97%)	20 (9.39%)	3 (1.41%)	3.38
6. GAI is easy to use.	115 (53.99%)	86 (40.38%)	11 (5.16%)	1 (0.47%)	3.48
Total	664 (51.96%)	494 (38.65%)	108 (8.45%)	12 (0.94%)	3.42

Statistical results can be derived from the charts. A total of 213 university students participated in the survey and filled out the questionnaire. In addition, more than half of the college students showed strong agreement with each survey question, and only a few participants showed disagreement or strong opposition. First, 53.05% of college students strongly agreed, and 38.05% of college students agreed that learning to use GAI was easy, with a mean of 3.43. Next, 51.17% of college students who participated in the survey strongly agreed that they could easily use GAI to accomplish what they wanted to do and have a mean of 3.4. Not only that, but 50.23% of the participants also strongly agreed that their interactions with GAI were clear and easy to understand, with a mean of 3.39. Obviously, the vast majority of participants agree with the ease of GAI. At the same time, only 10.33% of the college students who participated in the survey disagreed that their interaction with GAI was flexible, and it also had a high mean of 3.42. Also, 50.23% of the college students surveyed strongly agreed that GAI is easy to use proficiently, with a mean of 3.38. Finally, 40.38% of the universities surveyed agreed, and 53.99% of the universities surveyed strongly agreed that GAI is easy to use, with a mean of 3.48.

A detailed analysis will be carried out after the results of the survey are available. The survey surveyed 213 college students, and the questions of the survey mainly revolved around the difficulty of interaction, difficulty of use, and proficiency in the use of GAI. The statistical results show that for each question around the ease of use of GAI, the surveyed college students show a strong attitude towards ease of use, and the statistical average is at a high value. In addition, only a very small number of people believe that GAI is not easy to use and therefore maintain a negative attitude, which indicates that college students believe that GAI is easy to interact with, easy to use, and easy to use proficiently. Such findings are similar to those of another study, although the main group surveyed in this study is doctoral students. Through a variety of analyses, this study shows that Chat-GPT, as one of the typical representatives of GAI, is at a medium to high level in

behavioral intent, attitude, perceived usefulness, and perceived ease of use (Zou & Huang, 2023). This is further proof that GAI is easy to use, not only for PhD students but also for others, including university students, to become proficient in using GAI. As a result, college students can easily use GAI in their language learning. It can be seen from this that GAI has good ease of use.

3. What is the perceived acceptance of GAI in language learning?

Acceptance	Strongly Agree (SA)	Agree (A)	Disagree (D)	Strongly Disagree (SD)	Mean
1. I use the GAI every day in language learning.	95 (44.6%)	57 (26.76%)	56 (26.29%)	5 (2.35%)	3.14
2. I use the GAI for a variety of purposes in language learning.	100 (46.95%)	81 (38.03%)	29 (13.62%)	3 (1.41%)	3.31
3. I am resolved to continue using GAI in language learning.	105 (49.3%)	86 (40.38%)	19 (8.92%)	3 (1.41%)	3.38
4. The use of GAI has a more positive effect in language learning.	107 (50.23%)	92 (43.19%)	13 (6.1%)	1 (0.47%)	3.43
5. GAI is acceptable to use in language learning.	114 (53.52%)	87 (40.85%)	10 (4.69%)	2 (0.94%)	3.47
6. I recommend the use of GAI in language learning.	119 (55.87%)	79 (37.09%)	12 (5.63%)	3 (1.41%)	3.47
Total	640 (50.08%)	482 (37.72%)	139 (10.88%)	17 (1.33%)	3.37

The six items in the table reflect students' acceptance of the application of GAI to language learning. First of all, according to the results, 50.08% of the respondents strongly agree with each question, which reflects that students' acceptance of GAI is very high to some extent. Secondly, we can find that 44.6% of students agree to use GAI every day, and 26.76% agree to use GAI every day, and students have used GAI very frequently. On the other hand, the use of GAI by students is more diversified, and 46.95% of respondents strongly agree with the multifaceted use of GAI. Regarding the continuous use and positive impact of GAI, the proportion of people who strongly agree with it gradually increased, reaching 49.3% and 50.23%, respectively. Finally, regarding the acceptance and recommendation of GAI, the sum of respondents' agreement and strong agreement exceeds 90%, reaching 94.37% and 92.96%, respectively. On the whole, respondents' acceptance of GAI is very high.

Through continuous processing of the results and continuous analysis, more useful information can be obtained. This survey mainly targets college students, and the questions mainly focus on the acceptance degree of GAI among college students. According to the analysis of the results of six questions related to the acceptance of GAI by college students, the acceptance of GAI by college students is generally good. For all questions, the survey results show that the average acceptance of GAI among college students is at a high level, and the acceptance of GAI among students is already very high. However, there are still a small number of people who have not yet integrated GAI into their daily lives, which is the direction of future research efforts, and how to better apply GAI to students' daily language learning processes should be explored. According to Baytak (2023), the study's review of the literature shows that GAIs have been accepted in education but remain in doubt, and despite the incredible interest generated in these GAIs, there is still scepticism about their reliability. This idea coincides with the results of this survey. Although students' acceptance of GAI has been more comprehensive, there are still some attitudes that do not accept GAI. Therefore, it is necessary to conduct specific planning and research on the methods and rules of GAI in the future, so that GAI can better serve students and society.

V. CONCLUSION

This study set out to examine how most students of non-language majors perceive the usefulness, ease-of-use, and acceptance of Generative AI (GAI) in language learning. Overall, the survey results for non-English major IEC

students highlight the positive perception and wide acceptance of GAI in language learning. In the survey on the usefulness of GAI, 60.09% of the students strongly agree that GAI helps them complete tasks faster, and 56.34% of the students think that GAI improves their classroom performance, which indicates that GAI is beneficial and improves their foreign language learning efficiency to some extent. At the same time, in terms of ease of use in GAI language learning, students strongly agree with ease of use, believing that their interaction with GAI is clear and easy to understand, with an overall average of 3.42. Nevertheless, despite the overall positivity, it is noted that 10.88% of respondents disagree with the acceptance of GAI in language learning. More emphatically, among all the negative results of the survey questions, the proportion of people who disagree that use GAI every day in language learning reaches its peak, accounting for 26.29%. It can be inferred that the application of GAI in language learning has not reached a universally applicable level, which also reminds relevant fields that it is necessary to conduct specific research and development on the application methods and rules of GAI in language learning in the future so as to better serve students.

Altogether, this study identified that GAI has become an indispensable part of students' language learning because it does help them seek out the information they want more efficiently and promote their effectiveness in daily learning. However, although GAI is convenient and useful in the learning process, this study points out that further studies are still needed to consider whether students can rely on its help in continued and in-depth learning, depending on whether it can indeed improve their foreign language proficiency.

VI. RECOMMENDATION

Drawing upon the survey results and analysis, this paper presents the following recommendations to enhance and optimize the application of GAI in language learning from three perspectives: students, teachers, and other educational professionals, as well as software developers.

First of all, it is necessary for students to adapt to and accept the development of GAI in the age of information. At the same time, according to the survey of IEC students' acceptance of GAI's ease of use, this paper suggests that students should take the initiative to understand and learn how to use generative AI and carefully read its use tutorial so as to better apply it in language learning and improve the efficiency and effectiveness of learning.

In addition, teachers and related education experts should have a good understanding of the advantages and disadvantages of GAI, master its use methods, and systematically teach students to use it rationally. It is suggested that teachers can combine generative AI in the teaching process to explain interesting knowledge, such as how to use GAI to polish the expression of writing language, so that students can master language knowledge in practice and improve their learning enthusiasm.

Finally, it is recommended that software developers develop and optimize language learning-related functions in a targeted manner and provide specific instructions for learners to utilize. Particularly, the personalized learning experience necessitates further enhancement. Relevant corporate departments should consistently implement the feedback system and promptly collect user suggestions for timely adjustments and optimization.

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Based on Simulink Simulation of the Fuzzy PID Control for the TORA System

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***Keywords*— Translational oscillations with a rotational actuator (TORA) system, fuzzy PID (Proportion Integration Differentiation) control, triangle membership function, double S-type membership function, Simulink simulation**

***Abstract*—** *The purpose of this study is to control the TORA system through the MATLAB/Simulink simulation platform. The TORA system is a classical two-degree-of-freedom under-driven mechanical system, and this paper mainly focuses on the design of the control scheme for the swing angle of the ball. Firstly, the transfer function is established in the complex domain through the dynamical equations of the system. Then, the traditional PID controller, the triangular membership function fuzzy PID controller, and the double S type membership function fuzzy PID controller were designed. Finally, the simulation results are analyzed to compare the parameter performance of the three controllers. The fuzzy PID controller using the double S membership function is better than the other two controllers in terms of overshoot and adjustment time and has good practicability, stability, speed, and accuracy.*

I. INTRODUCTION

Translational oscillators with a rotational actuator (TORA) were originally used as a simplified model for studying the natural vibration phenomenon of dual spin spacecraft. Due to their outstanding characteristics such as light weight, low energy consumption, low cost, and strong flexibility, they have been widely used in aerospace [1, 2, 3], defense and military industry [4], mechanical manufacturing [5], and other fields. It is currently commonly used as a nonlinear benchmark system for nonlinear controller design, verification of the control performance of nonlinear control algorithms, or teaching research. This study simplifies the model of a dual-spin spacecraft to consist of an unpowered small car and a driven small ball [15].

The TORA system is a typical underactuated mechanical system that can serve as a benchmark system in control theory research for validating different algorithms. In the initial TORA system, the ball rotated in the horizontal plane, and currently, many scholars have studied the problem of the ball's rotation in the vertical plane. The control methods of the TORA system mainly include the PID method [6], feedback method [7], back-stepping method, energy-based control method [8], and sliding mode control method [9, 10, 11, 12].

This study first analyzes the dynamic equations of the vertically underactuated TORA system and then establishes a simulation model, mainly using traditional PID controllers and fuzzy PID controllers to control the TORA system. In order to further compare the

performance of controllers, a comparison was made between triangular membership functions and double S-shaped membership functions in the design of fuzzy PID controllers [13, 14]. Finally, a simulation model was established using the Simulink module of MATALAB to conduct simulation experiments on the TORA system.

II. TORA SYSTEM MATHEMATICAL MODELING

The model parameters of the TORA system are: car mass M=1.3608 kg, ball mass m=0.096kg, counterclockwise rotation angle θ (rad) from the vertical downward direction, radius of ball rotation r=0.0592 m, distance of car movement x(m), input torque τ(N·m), car friction coefficient *f*=0.1N/m/sec, spring elasticity coefficient k=186.3N/m, center of mass rotational inertia J=0.0002175kg*m^2, and gravity acceleration g=9.8 N/ m^2. The TORA system is shown in Figure 1. It is composed of a small car in a horizontal direction and a small ball in a circular motion inside the car, and the left end of the car is connected to the wall through a spring. Drive the small ball in a circular motion to move the car horizontally. Dynamically model the TORA system using the Lagrange equation.

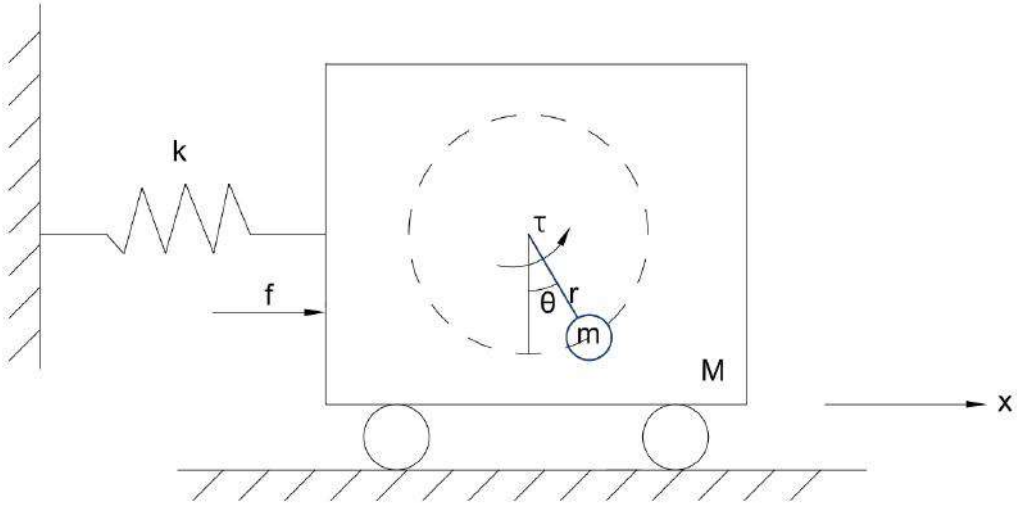

Fig.1 TORA System Schematic Diagram

Firstly, the sum of the kinetic energy of the car and the kinetic energy of the ball is the total kinetic energy K of the TORA system, that is:

$$\mathrm{K}=\frac{1}{2}(M+m)\dot{x}^2+mr\dot{x}\dot{\theta}\theta+\frac{1}{2}(M+m)\dot{\theta}^2+mgr\cos\theta-\frac{kx^2}{2} \quad (1)$$

We taking the horizontal plane as the reference plane for gravitational potential energy, the car moves on the horizontal plane and therefore do not possess gravitational potential energy. So the gravitational potential energy *P* of the TORA system is the sum of the gravitational potential energy of the ball and the elastic potential energy of the spring, that is:

$$\mathrm{P}=-mgr\cos\theta+\frac{kx^2}{2} \quad (2)$$

The Lagrangian operator function of the TORA system is

$$L=K-P \quad (3)$$

According to the Lagrangian equation, the dynamic equation of the TORA system is

$$\begin{cases}\dfrac{d}{dt}\left(\dfrac{\partial L}{\partial \dot{x}}\right)-\dfrac{\partial L}{\partial x}=f\\ \dfrac{d}{dt}\left(\dfrac{\partial L}{\partial \dot{\theta}}\right)-\dfrac{\partial L}{\partial \theta}=r\end{cases} \quad (4)$$

Substituting equations (1), (2), and (3) into equation (4) yields the dynamic model of the TORA system as follows

$$(M+m)\ddot{x}+mr\cos\theta\,\ddot{\theta}-mr\sin\theta\,\dot{\theta}^2+kx=f \quad (5)$$

$$mr\cos\theta\ddot{x}+(mr^2+J)\ddot{\theta}+mgr\sin\theta=\tau \quad (6)$$

In a vertical TORA system, our control objective is to place the system at a stable equilibrium point. When we substitute the following data $(\dot{x}=0,\ddot{x}=0,\dot{\theta}=0,\ddot{\theta}=0,\tau=0)$ into equation (1), we can obtain a stable equilibrium point$(\dot{x},\ddot{x},\dot{\theta},\ddot{\theta})=(0,0,0,0)$, that is, when the

ball is in a vertical downward position.

At this point, we linearize the TORA system. When the small ball is infinitely close to the vertical downward position, i.e., θ is infinitely close to 0, then there is, $cos\,\theta \approx 1, sin\,\theta = \theta, (d\theta/dt)^2 = 0$ which is introduced into equations (5) and (6), resulting in

$$(\mathrm{M}+\mathrm{m})\ddot{x} + mr\ddot{\theta} + kx = f \quad (7)$$

$$\mathrm{mr}\ddot{x} + (mr^2 + J)\ddot{\theta} + mgr\theta = \tau \quad (8)$$

In the TORA system, when the car is moving horizontally, it will generate frictional force with the horizontal plane to hinder the car's movement. The frictional force in this article is

$$f = -\mu\dot{x} \quad (9)$$

Perform the Laplace transform on equations (7), (8), and (9) to obtain

$$(M+m)s^2X(s) + mrs^2\theta(s) + kX(s) = -\mu sX(s) \quad (10)$$

$$mrs^2X(s) + (mr^2 + J)s^2\theta(s) + mgr\theta(s) = \tau(s) \quad (11)$$

Equation (10) can be written in the following form:

$$\frac{x(s)}{\theta(s)} = -\frac{mrs^2}{(M+m)s^2 + \mu s + k} \quad (12)$$

Substituting equation (12) into equation (11) with the control input yields

$$\frac{\theta(s)}{\tau(s)} = \frac{\frac{(M+m)}{w}s^2 + \frac{\mu}{w} + \frac{k}{w}}{s^4 + \frac{\mu(mr^2+J)}{w}s^3 + \frac{[k(mr^2+J)+mgr(M+m)]}{w}s^2 + \mu\frac{mgr}{w}s + \frac{kmgr}{w}} \quad (13)$$

Among them, $w = [(M+m)(mr^2+J) - m^2r^2]$.

Substitute the parameters of the TORA system into equation (13) to obtain the open-loop transfer function for the swing angle θ and input torque τ of the ball, which is:

$$G(s) = \frac{\theta(s)}{\tau(s)} = \frac{2630s^2 + 180s + 336315}{s^4 + 0.07s^3 + 333s^2 + 10s + 18731} \quad (14)$$

III. TORA SYSTEM CONTROLLER PRINCIPLE

3.1 Principle of Traditional PID Control

In general control systems, the most common control method is to use traditional PID control (Figure 2).

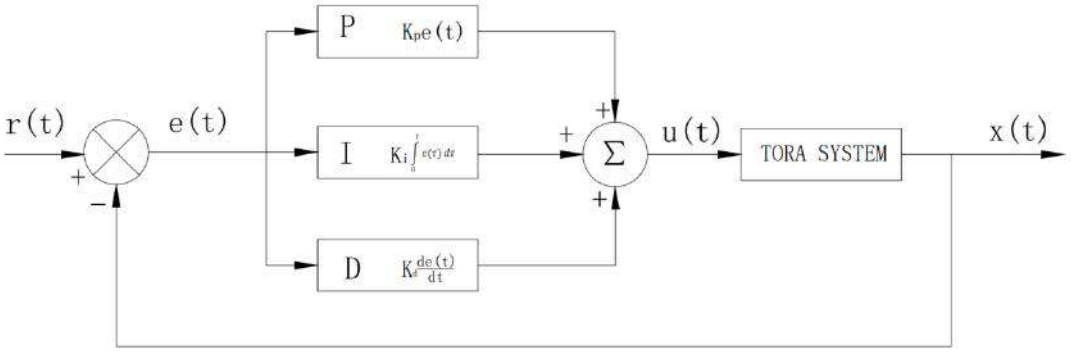

Fig.2 Principle Framework Diagram of Traditional PID Control System

The traditional PID controller is a linear controller that forms the control deviation e of the controller based on the difference between the given input value r(t) and the actual output value u(t). The output error equation of the traditional PID controller is as follows:

$$e(t) = r(t) - u(t) \quad (15)$$

The control equation of a traditional PID controller is as follows:

$$u(t) = K_p e(t) + K_I \int_0^t e(t)dt + \frac{K_D de(t)}{dt} \quad (16)$$

In the above equation, K_p is a proportional coefficient, K_I is an integral coefficient, and K_D is a differential coefficient. The proportional coefficient is the amplification factor of the difference between the preset value and the feedback value, and the larger the proportion, the higher the adjustment sensitivity. The integration coefficient accumulates the difference between the preset value and the feedback value over time, but there is a significant lag. The differential coefficient is the rate of change of the research object (i.e., the difference between the two differences before and after), and a corresponding adjustment action is given in advance based on the rate of change of the difference. According to the control laws of each coefficient, it can be seen that the proportional coefficient makes the reaction faster, the differential coefficient makes the reaction earlier, and the integral coefficient makes the reaction lag. Within a certain range, the larger the value of K_p and K_D, the better the

adjustment effect.

3.2 Principle of Fuzzy PID Control

Fuzzy PID control is a control method that combines fuzzy logic and classical PID controllers. A PID controller is a common feedback controller that adjusts the control output based on the size of the error signal to make the system output value close to the expected value. The PID controller consists of a proportional term (P), an integral term (I), and a differential term (D). Fuzzy control mainly consists of three steps: fuzzification, determining fuzzy rules, and deblurring. The control framework diagram for fuzzy PID control is shown as Figure 3.

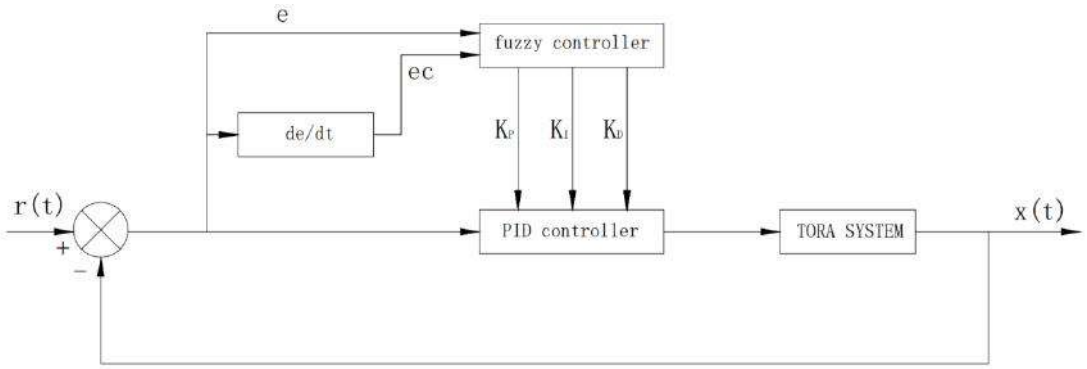

Fig.3 Fuzzy PID Control Block Diagram

In the above figure, e represents the control error, and ec represents the rate of change of the control error. In a fuzzy PID control system, e and ec are used as the two input variables of the controller, and the differential coefficients (K_p 、K_I 、K_D) are used as the three output variables of the controller.

IV. DESIGN OF FUZZY PID CONTROLLER

In this article, the fuzzy PID controller is a two-input, three-output type. The basic domain of error e is taken as [-0.6, 0.6], the basic domain of error rate of change is taken as [-0.6, 0.6], and the domain of output variables is taken as [-3, 3]. Divide the fuzzy domain of input and output variables into 7 fuzzy subsets, namely NB, NM, NS, ZO, PS, PM, and PB.

In fuzzy set theory, the membership function refers to a function used to measure the degree of membership of an element to a fuzzy set. It is one of the most basic concepts in fuzzy sets, used to describe the degree of membership of elements in a certain fuzzy set. In this study, the triangular membership function (trimf) and double S-type membership function (dsigmf) are used as the membership functions of the fuzzy PID controller. Compare the results of two types of membership functions and choose the one with the best control effect as the membership function of the fuzzy PID controller. Their membership function diagrams are as follows (Figure 4, 5):

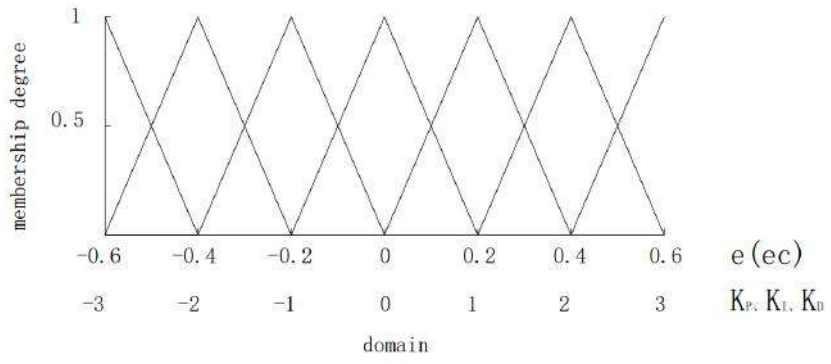

Fig.4 Triangle Membership Function Diagram

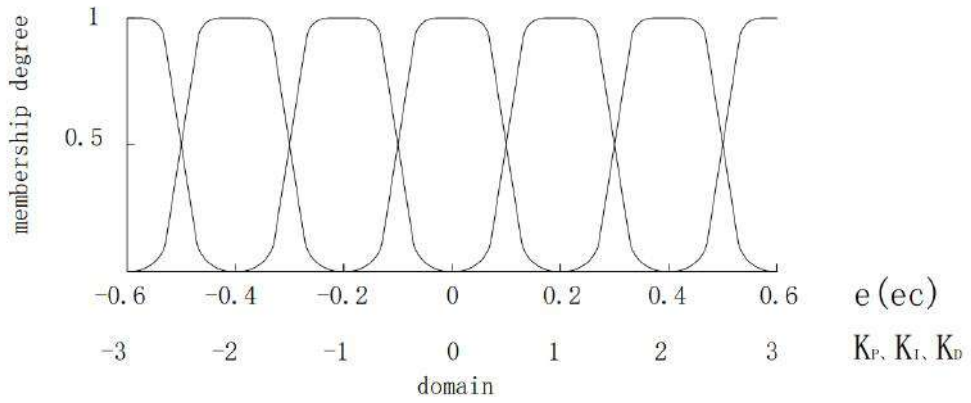

Fig.5 Double S-shaped Membership Function Diagram

Control rules are usually established by experts based on long-term experience. By determining the input and output quantities of the fuzzy controller, a fuzzy subset is determined. Based on the fuzzy rules established above, a rule table for the fuzzy PID controller is established, as shown below (Table 1, 2, 3).

Table 1 K_p Fuzzy Rule Table

K_P E / EC	NB	NM	NS	O	PS	PM	PB
NB	PB	PB	PB	PB	PM	PS	O
NM	PB	PB	PB	PB	PM	O	O
NS	PM	PM	PM	PM	O	PS	PS
O	PM	PM	PS	O	NS	NS	NM
PS	PS	PS	O	NS	NM	NM	NM
PM	PS	O	NS	NM	NM	NM	NB
PB	O	O	NM	NM	NM	NB	NB

Table 2 K_I Fuzzy Rule Table

K_I E / EC	NB	NM	NS	O	PS	PM	PB
NB	NB	NB	NM	NM	NS	O	O
NM	NB	NB	NM	NS	NS	O	O
NS	NB	NM	NS	NS	O	PS	PS
O	NM	NM	NS	O	PS	PM	PM
PS	NM	NS	O	PS	PS	PM	PB
PM	O	O	PS	NM	PM	PB	PB
PB	O	O	PS	PM	PM	PB	PB

Table 3 K_D Fuzzy Rule Table

K_D E / EC	NB	NM	NS	O	PS	PM	PB
NB	PS	NS	NB	NB	NB	NM	PS
NM	PS	NS	NB	NM	NM	NS	O
NS	O	NS	NM	NM	NM	NS	O
O	O	NS	NS	NS	NS	NS	O
PS	O	O	O	O	O	O	O
PM	PB	PS	PS	PS	PS	PS	PB
PB	PB	PM	PM	PM	PS	PS	PB

This design system uses the Mamdani inference method to perform fuzzy inference on the established fuzzy rules in order to obtain control variables.

V. TORA SYSTEM SIMULATION AND RESULT ANALYSIS

This study based on the established control model and controller, conduct simulation analysis on the TORA system. The control model was built using the Simulink module of MATLAB, and two different membership functions of fuzzy PID and traditional PID were compared and analyzed. The system control model built is shown in Figure 6,7,8.

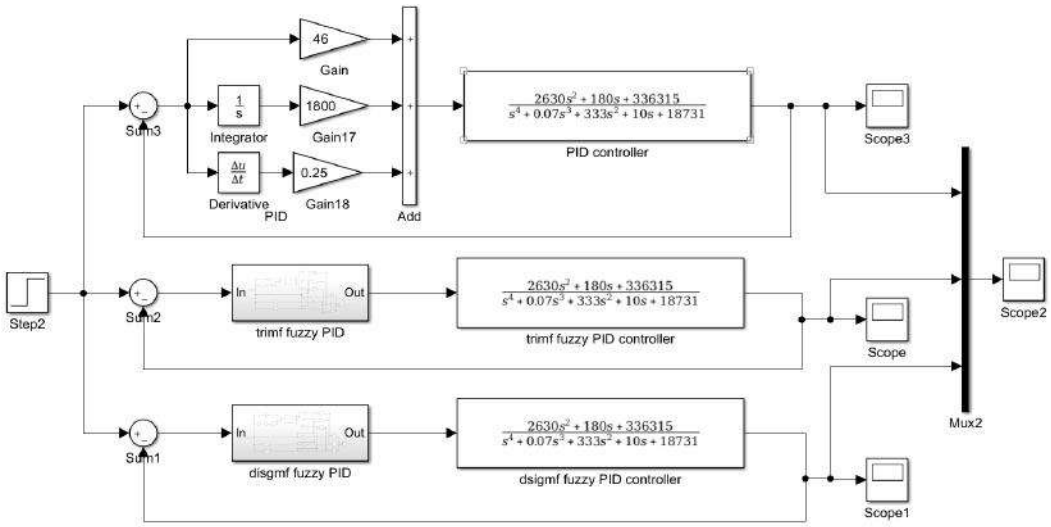

Fig.6 Simulink Simulations of Traditional PID and Fuzzy PID Control Systems (Ball Angle)

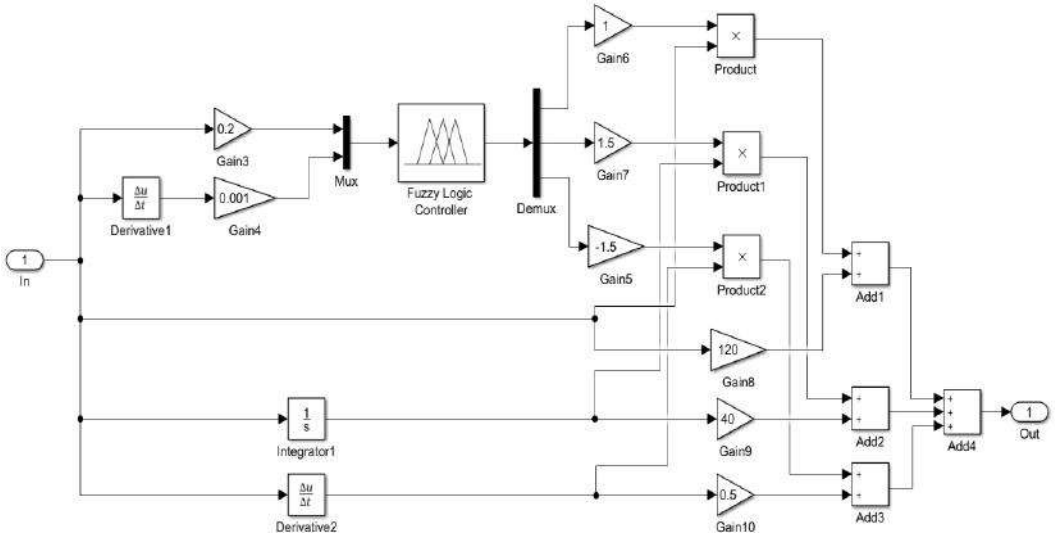

Fig.7 Simulink Simulation of Fuzzy PID Controller for Ball Angle

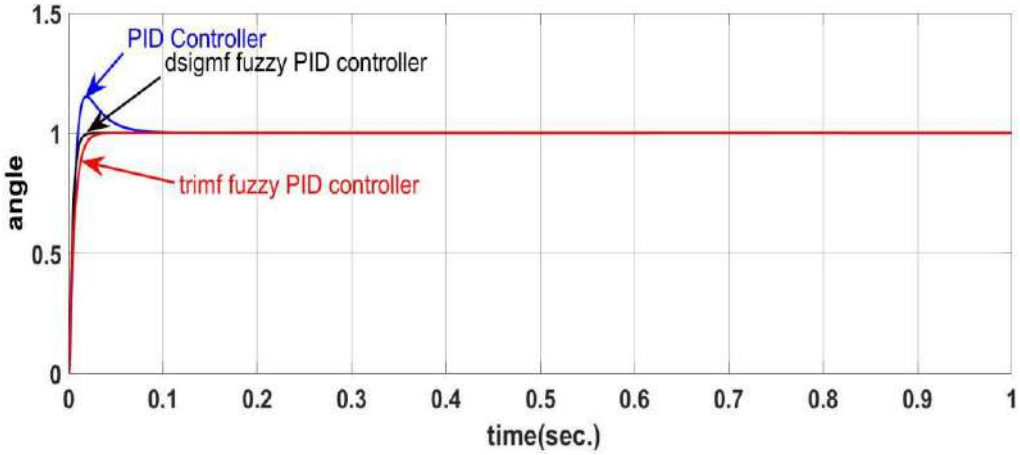

Fig.8 Response Curves of Traditional PID and Fuzzy PID Controller Systems (Ball Angle)

Through simulation using MATLAB/Simulink modules, it has been found that with appropriate parameters, traditional PID controllers have good control effects on control objects that can assume precise mathematical models. They can meet the requirements of system control accuracy and rise time, but there are problems such as long adjustment times. As shown in Table 4, two fuzzy PID controllers with different membership functions can adjust the PID parameters of the system in real time. By doing so, the PID parameters can be more suitable for the control requirements of the system, resulting in better control effects than traditional PID controllers. Moreover, the fuzzy PID controller using dual S-type membership functions performs the best among the three controllers.

Table 4 Comparison of Performance Parameters

Method	Rise time (s)	Overshoot (%)	Adjusting time (s)
Tradition PID	0.02	17	0.09
Fuzzy PID(trimf)	0.08	1	0.08
Fuzzy PID(dsigmf)	0.06	0.5	0.06

VI. CONCLUSION

The inherent TORA system is a typical two-degree-of-freedom underactuated mechanical system. This study analyzes the motion of the TORA system, establishes a mathematical model of the TORA system

using the Lagrange method, and designs a PID controller and two types of fuzzy PID controllers to control the TORA system. By adjusting their proportional constant, integral constant, and differential constant parameters, fuzzifying the fuzzy PID controller, designing fuzzy rules, and defuzzifying, them the TORA system can quickly and accurately reach a stable state, ultimately achieving a stable system.

The superiority of the fuzzy PID controller with dual S-type membership functions over the other two controllers was verified through Simulink simulation. Under the action of the fuzzy PID controller with dual S-type membership functions, the system has fast response speed, short adjustment time, and high steady-state accuracy, achieving the expected goals.

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Improving Cyber Security: Artificial Intelligence's Ability to Detect and Stop Threats

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***Keywords*— Cyber Security, Artificial Intelligence, Threat identification, Predictive modeling, Machine learning**

***Abstract*—** *Artificial intelligence has become a crucial element of cyber security because of its capacity to assess security threats instantly and respond appropriately. Nowadays, AI plays a more significant role in identifying and thwarting attacks that keep companies innovative. The primary goals of artificial intelligence in cybersecurity are threat identification and mitigation. Artificial intelligence uses machine learning algorithms and sophisticated data analysis to identify patterns and abnormalities in user behavior and network traffic that can point to a possible cyberattack. Artificial Intelligence can help stop attacks by using predictive modeling. AI is also capable of anticipating dangers and preventing them by analyzing historical attacks and finding patterns. Automated incident response system creation is just another crucial cybersecurity use of artificial intelligence. These systems can assess data, spot possible threats, and then take action to lessen the impact of the attack by containing it or mitigating its effects. Artificial intelligence must be used by businesses in cybersecurity to safeguard their networks and sensitive data against ever-evolving online threats. Artificial intelligence (AI) is quickly emerging as a crucial tool for effective cybersecurity in today's digital environment due to its capacity to evaluate massive volumes of data in real-time and automate incident response. The importance of artificial intelligence (AI) in cybersecurity, particularly its applications in threat identification and defense.*

I. INTRODUCTION

In the battle against cybercrime, artificial intelligence is emerging as a significant technological tool. Artificial intelligence-based cybersecurity solutions can assist enterprises stay ahead of cyber-attacks by automating response actions, and detecting and preventing threats in real time (Srivastava et al., 2021).

Traditional security methods are no longer adequate to ward against sophisticated cyber threats since cybercrime has expanded quickly (Samiullah, 2019a). Because AI can evaluate and identify threats, forecast future assaults, and automate reaction measures, it is an essential tool for cybersecurity. Cybersecurity solutions powered by AI can be used.

Using machine learning and deep learning algorithms, a lot of data and information can be analyzed to find patterns and abnormalities that could be signs of possible cyber threats (Battelle et al., 2019a). These solutions are especially helpful in identifying new and developing threats that conventional signature-based methods might miss. AI can also detect patterns, quickly analyze massive amounts of data, and learn from past mistakes to foresee and stop attacks in the future. Artificial intelligence (AI)--

driven problem detection can quickly identify potential threats and reduce the amount of time needed to identify and resolve the issue.

The primary focus is on automating threat detection and response.

AI is always able to react to threats in real time, and automation can help speed up response times as well. By reducing the need for human analysts, this automation can also assist businesses in lowering their cybersecurity expenses (Xiaoguang et al., 2021). By locating weaknesses in various systems and networks, AI can assist enterprises in strengthening their security posture. AI can detect possible weak points in a network and provide ways to counteract threats by analyzing the network traffic (Sadiku et al., 2020a). Organizations that adopt this cybersecurity strategy can stop attacks in their tracks.

Businesses are increasingly depending on artificial intelligence in cybersecurity to secure their networks and sensitive data from ever-increasing cyber threats.

By employing AI to identify and stop assaults in real time, organizations can take preemptive measures to reduce the risk of data loss and disruption (Oku tan & Eyüpoglu, 2021).

The use of artificial intelligence in cybersecurity is crucial for the development of automated incident response systems.

These systems can assess the information, spot possible threats, and then take action to lessen the attack's impact by containing it or mitigating its effects. If attacks become widespread, this is crucial. It's possible that human help won't be able to react quickly enough. There are benefits and drawbacks to using AI in cybersecurity (Zhang, Hamadi, et al., 2022). Threat intelligence is the most crucial use of AI in cybersecurity. Massive volumes of data from several sources can be analyzed by AI to find patterns and trends that point to possible cyberthreats (Sahoo & Yadav, 2022). Artificial Intelligence (AI) can assist firms in staying ahead of cybercriminals by anticipating and averting future attacks by evaluating this data. Through the provision of up-to-date information on emerging threats, this threat intelligence can assist businesses in strengthening their incident response capabilities. AI can enhance cybersecurity by enhancing access control systems and authentication procedures (Abbas et al., 2019). Organizations can guarantee that only authorized users have access to their systems and networks by implementing AI-based biometric authentication solutions. Through the analysis of user behavior and the recognition of patterns that point to possible risks, these systems are also capable of detecting and stopping unwanted access attempts. By identifying and addressing vulnerabilities at the device level, AI can help improve end-point security (Zhang, Ning, et al., 2022).

II. TECHNIQUES OF ARTIFICIAL INTELLIGENCE REGARDING CYBERSECURITY

Cybersecurity has undergone a revolutionary change thanks to AI technology. These methods provide cybersecurity experts the ability to examine vast volumes of data, spot trends, and abnormalities, and recognize possible risks before they materialize into actual attacks (Thuraisingham, 2020). The AI methods listed below are frequently employed in cyber security.

Machine Learning

This kind of AI allows computers to learn from data without the need for explicit programming. In order to discover trends and identify potential risks, machine learning algorithms are trained on vast datasets of both benign and malicious traffic (Merat & Almuhtadi, 2015). Applications of machine learning include virus, anomaly, and network intrusion detection.

Natural Language Interpretation

It's a subset of artificial intelligence (AI) that lets computers comprehend and interpret human language. NLP is used in cybersecurity to look for possible vulnerabilities in unstructured data sources like online forums and social media feeds.

In-depth Learning

It is a branch of machine learning that makes use of deep neural networks to extract intricate patterns from data. It is employed in cybersecurity to carry out activities such as fraud, phishing, and virus detection.

Learning via Reinforcement

This subgroup of ML places a strong emphasis on judgment.

Systems can be trained to respond to attacks in cybersecurity by using reinforcement learning, which takes into account the circumstances and perceived threat level of each attack.

Computer Vision

It's an AI method that lets computers examine and interpret visual data. It is employed in cybersecurity for activities such as video monitoring and facial recognition.

Skillful Frameworks

These artificial intelligence (AI) systems imitate human decision-making abilities in a certain field. These systems are utilized in cybersecurity for activities including

vulnerability assessment and intrusion detection and response.

III. ARTIFICIAL INTELLIGENCE-BASED THREAT DETECTION

Be it homeland security, cybersecurity, or physical security. A vital part of maintaining the security of individuals and organizations is threat detection. Artificial intelligence technology advancements have made it easier to identify and eliminate risks in real-time (Shamiulla, 2019b). Threat detection systems based on artificial intelligence (AI) enable security systems to identify threats and hazards more quickly, accurately, and effectively. With the use of algorithms and machine learning approaches, AI-based threat detection systems may identify patterns in vast amounts of data that may indicate possible threats (G. A., 2022). A variety of data sources, including social media feeds, network traffic, and video surveillance footage, can be utilized to train AI systems to recognize and alert security professionals.

The algorithms are capable of learning from large data sets and identifying minute patterns thanks to the application of deep learning techniques.

This could imply that one of the most crucial elements of AI-based threat identification is potential hazards. Deep learning uses neural networks to mimic the way the human brain learns, enabling algorithms to improve in accuracy over time by identifying and assimilating new data points (Rehman, 2022). Thanks to AI-based threat detection, which is very good at identifying threats in real time, security teams can react quickly and prevent potential dangers from turning into big security events. These systems can detect and follow threats across several systems and networks because they can analyze data from multiple sources at once.

Threat detection systems that use artificial intelligence (AI) can identify a wide range of threats, depending on the data and algorithms that are used. For instance, these technologies are capable of identifying phishing schemes, malware, and other internet hazards (Kuzlu et al., 2021). In the context of physical security, artificial intelligence (AI) can identify questionable activities or behavior in video surveillance footage, such as theft or unlawful access. In homeland security, artificial intelligence (AI) can analyze social media feed data to find possible terrorist threats. The use of AI in danger detection has various benefits. Due to the effectiveness and precision of AI-based solutions, security personnel can quickly identify risks and take appropriate action. These systems' rapid mass data analysis capabilities make them ideal for evaluating data from multiple sources simultaneously. AI systems can also get more accurate over time by picking up new information and adjusting to it, which reduces the likelihood of false positives (Sadiku et al., 2020b).

IV. ARTIFICIAL INTELLIGENCE BASED CYBER SECURITY ASPECTS

Our civilization is evolving quickly as a result of computer technology advancements (Mehra & Badotra, 2021). The impact of this on people's daily routines and employment is substantial. Some of these technological advancements have made it feasible to create computers with cognitive functions like learning, decision-making, and problem-solving that are comparable to those of humans.AI is capable of analyzing vast volumes of data and applying intelligence to make decisions instantly. The application of AI techniques is beneficial to several technological and scientific domains (Achi et al., 2021). It is no secret that there is a lot of personal data on the Internet, which causes a lot of cybersecurity issues. First of all, manual analysis is nearly difficult due to the volume of data. Second, there might be risks related to AI or emerging risks. In addition, the high cost of employing experts drives up the cost of averting threats (Ansari et al., 2022). It also takes a great deal of time, money, and effort to design and implement the algorithms needed to recognize those threats.

One way to address those issues is to use AI-based methods. AI can analyze large amounts of data fast, accurately, and effectively

(Cyber_Security_Based_on_Artificial_Intelligence_for_Cyber-Physical_Systems, n.d.). Using threat history, an AI-based system can forecast future attacks that will resemble past ones, even if the patterns of those attacks differ. AI is able to manage enormous amounts of data, identify fresh, noteworthy variations in attacks, and continuously enhance the way its security system responds to dangers.

The use of AI in cybersecurity has transformed the conventional security strategy from reactive to proactive, helping to identify and mitigate threats in real-time (Rawat et al., 2022).

Here are a few cybersecurity techniques that use AI:

- Threat Identification and Evaluation

Large volumes of data can be automatically analyzed by AI-based threat detection systems to find possible security risks. Machine learning algorithms are able to recognize malicious code in network traffic and discover trends and anomalies in files and examine user conduct to identify any questionable conduct (Bishtawi & Alzubi, 2022).

- Fraud Identification

Massive data sets can be analyzed by AI-based fraud detection systems to find fraudulent activity or transactions. According to Benzaïd and Taleb (2020), these systems have the ability to recognize anomalous patterns, behaviors, and trends in financial transactions, which can aid in the prompt detection of fraud.

- Analytics of User and Entity Behavior

UEBA is an AI-based method that looks for unusual activity and behavior in user accounts and devices using machine learning algorithms. It can identify compromised accounts or malevolent insiders, which are difficult to find using conventional security techniques.

- Incident Response

Systems powered by AI can automate the reaction to cyberthreats, cutting down on the amount of time needed to counter an attack. These technologies are capable of analyzing data from multiple sources and giving the security team useful insights so they can act promptly and appropriately (Bhatele et al., 2019b).

- Virtual assistants and chatbots

Routine security chores, including account management and password resets, can be automated with the use of chatbots and virtual assistants driven by artificial intelligence. Additionally, they can offer users immediate support, enabling them to swiftly address security-related problems.

- Cybersecurity Intelligence

Massive volumes of data from several sources can be analyzed by AI-based threat intelligence systems to find new threats and vulnerabilities (Li, 2018). They have the ability to offer enterprises proactive protection against cyber threats by providing real-time threat intelligence.

V. DISCUSSION

Artificial intelligence has emerged as a key instrument in the cybersecurity space in recent years (Rekha et al., 2020). Due to the daily increase in the volume and complexity of cyber threats, organizations have begun utilizing AI-based systems for the detection and prevention of cyberattacks.

a) AI-powered threat detection

Threat detection is AI's main function in cybersecurity.

In the past, threat detection systems have mostly relied on signature-based techniques, which are limited to identifying known threats. However, because cyber threats are becoming more sophisticated, these measures are no longer as effective.

One of the most popular AI methods for threat detection is machine learning (Ghillani, 2022). Massive data sets can be analyzed by ML models, which can then be used to spot patterns that point to potential threats. The models are able to effectively identify possible threats since they are trained on datasets containing both benign and malicious traffic. ML models, for instance, are able to identify unusual network activity that can point to a possible hack. Another artificial intelligence method for danger detection is deep learning. Deep Learning models classify and analyze data using deep neural networks. These models may identify complex patterns and classify them as either positive or negative.

For example, deep learning models are capable of identifying and classifying phishing scams, malware, and other online dangers. Another AI technology used in threat detection is Natural Language Processing (NLP). To find possible risks, NLP algorithms can examine unstructured data sources like internet forums and social media feeds. The accuracy of threat detection can be increased by the algorithms' ability to extract information from text data (Alhayani et al., 2021).

b) AI-based threat prevention

AI can also be utilized for threat prevention in addition to danger detection. AI-based systems are able to recognize possible dangers and take preventative action before they have a chance to do any damage.

Here are some instances of how artificial intelligence is being used to counter threats:

1. Intrusion Prevention: Systems that employ artificial intelligence to prevent intrusions can identify and neutralize them before they have a chance to infiltrate the network.

2. Malware Prevention: AI-driven anti-malware programs are able to identify and stop malicious software from being installed.

3. Phishing Prevention: By examining emails and spotting questionable content, AI-based ant phishing systems may identify and stop phishing assaults.

4. Vulnerability Assessment: AI-based vulnerability assessment systems are capable of seeing possible network vulnerabilities and taking preventative action to lessen them.

AI-powered access control systems have the ability to recognize possible hazards and prevent unauthorized individuals from entering.

VI. CONCLUSION

The role that artificial intelligence will play in cybersecurity is rapidly evolving and growing in significance.

Because cyber threats are so sophisticated and dynamic, traditional approaches to threat detection and prevention are no longer sufficient. Artificial intelligence (AI) technologies offer sophisticated and innovative ways to thwart cyberattacks. Artificial intelligence (AI)-based systems use techniques including machine learning, deep learning, natural language processing, predictive analytics, and behavioral analytics to detect and block cyber threats.

These systems are capable of analyzing massive amounts of data, identifying patterns, and making predictions that are not possible with traditional methods.

Furthermore, because AI-based systems can recognize and neutralize both known and unknown threats, they are a helpful tool for companies looking to stay ahead of cyberattacks. Because they may be used for access control, vulnerability assessment, intrusion prevention, malware protection, and phishing prevention, these systems offer an all-in-one cybersecurity solution.

As technology advances, so too will the use of AI in cybersecurity. Companies will need to adjust and use these state-of-the-art solutions if they want to ensure that their systems are protected from cyberattacks. AI is expected to become a critical component of cybersecurity in the near future, and businesses that invest in these technologies will have enhanced defenses against cyberattacks.

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A Discussion About Strategies for Economic Recovery Post-COVID-19 Pandemic

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***Abstract*—** *In December 2019, the covid-19 pandemic had a significant impact on the global economy. The objective of this study is to identify the strategies used for economic recovery after the crisis, differentiating the implemented actions and analyzing how GDP, unemployment, and inflation reacted to the events. Using a qualitative approach, countries that were positively and negatively affected were selected, observing their different political approaches, and determining the most efficient ones. Additionally, the fiscal and monetary policies implemented in these countries were compared. The main economic indicators analyzed were GDP, unemployment, and inflation. Considering that the study is a comparison between the same countries before and after the pandemic and does not focus on absolute numbers of the mentioned indicators, the results suggest that even geographically close countries achieved different outcomes. Countries with more liberal labor markets and those that invested in professional qualification and internal infrastructure showed more positive results in the proposed indicators. Furthermore, since the covid-19 pandemic had a significant impact on the global economy, the study discusses the adopted strategies of fiscal and economic policies and their importance in differentiating the economic recovery among countries, as well as the relationship between inflation and recovery policies.*

I. INTRODUCTION

Throughout the 20th century, moments of economic rise were witnessed, such as the post-World War II Capitalist Golden Age, marked by the vigorous growth of the United States and other industrial powers [7]. However, economic disasters were also faced, such as the Great Depression of 1929 and the more recent financial crisis of 2008, triggered by the housing bubble in the United States [14].

In the 21st century, health crises have taken on a new relevance, not seen on a large scale since the Spanish flu at the beginning of the 20th century, highlighted by the speed with which they spread globally. The COVID-19 pandemic is the most recent and striking example and object of study, causing not only a public health crisis, but also triggering significant economic consequences on a local and global scale [15]. Countries around the world have faced unprecedented challenges, with varying impacts on key economic indicators such as Gross Domestic Product (GDP) [21] and unemployment and inflation rates [8].

In the face of these crises, fundamental questions arise about how the role of the State impacts the economy and what strategies are to face adversities, seeking a quick recovery. This research aimed to identify which public and monetary policies were adopted by different countries and

economic blocs to mitigate the impacts of crises and promote economic recovery. Through the analysis of significant economic indicators, recently mentioned, and implemented policies, we sought to understand how these actions affected the flexibility and adaptation of the market to the adverse conditions imposed by the health crisis established in the world in 2020 with the COVID-19 pandemic.

The research methodology adopted to compose the research included a qualitative approach [5], of a descriptive nature [9], based on the analysis of existing data and the bibliographic review of sources. The aim was to provide an in-depth understanding of political and economic responses to crises, using reliable and reliable sources, such as reports from international multilateral organizations and official government data.

This is expected to enable the discussion of valuable results to guide future political decisions and economic strategies in the face of similar crises. With an analysis based on data and based on economic theories, the study seeks to contribute to the development of effective policies for economic recovery and preparation for possible future crises.

II. DISCUSSIONS

A comparative analysis of recessions throughout the 20th and 21st centuries reveals a series of patterns and nuances that highlight the complexity of economic crises. By examining historical events such as the Spanish flu [3], the crises of 1929 [13] and [14], and the recent recession caused by the COVID-19 pandemic, it is possible to identify points of convergence and distinction that shed light on the underlying mechanisms and policy responses adopted in the face of such challenges.

Recessions resulting from biological agents, such as the Spanish flu and COVID-19, stand out for their unpredictability of a biological agent and global scope with rapid spread. The sudden emergence of these pandemics generated immediate impacts on economic indicators, reflected in falls in the Gross Domestic Product (GDP), increased unemployment [19] and inflationary pressures. Although historical data estimates are scarce, it is possible to draw parallels between the economic effects of these crises, as done by [2], showing a significant reduction in GDP per capita and disturbances in the production and distribution chains.

Comparatively, recessions originating from financial crises, such as those of 1929 and 2008, have similarities in economic impacts, but differ in terms of predictability. While the speculative bubbles that led to the crises [20] were largely identified by economists and market observers, the magnitude and exact timing of the collapse were difficult to predict. These crises triggered sharp declines in GDP, rising unemployment and global financial instability.

A quantitative analysis of the economic impacts of these recessions reveals a variety of scenarios. The 1929 crisis was characterized by an abrupt drop in GDP and a significant rise in unemployment, the effects of which lasted for years. The 2008 crisis, centered on the collapse of the real estate and financial markets, generated a prolonged recession, with repercussions on several sectors of the economy. In contrast, the 2020 recession, triggered by the pandemic, demonstrated a more immediate economic response, with significant drops in GDP and an increase in unemployment, followed by stimulus and recovery measures.

The implementation of economic policies to address these crises reflects both similarities and contextual adaptations. Government responses to the 1929 and 2008 crises included budget balancing measures, spending restraint and fiscal stimulus to rescue affected sectors. In the case of the 2020 recession, fiscal stimulus, interest rate reduction and liquidity injection policies were adopted on a global scale, aiming to mitigate the immediate impacts of the pandemic and promote economic recovery.

Although economic policies share common elements, such as stimulating aggregate demand and supporting the financial system, their applications vary according to the specificities of each crisis. The response to the COVID-19 pandemic highlighted the importance of agile and adaptable measures, such as lines of credit for companies and direct financial support to the population, especially the most exposed portion, reflecting the disruptive and unpredictable nature of the crisis.

Furthermore, in terms of the economic indicators listed and the data from [2], [11], [13], [14], [17] and [18], Table 1 was constructed, summarizing how the last three major crises unfolded.

Finally, regarding comparative analyzes of recessions throughout the 20th and early 21st centuries, recurring patterns and contextual adaptations in the economic response to crises are revealed. Understanding these historical events and their implications offers valuable insights to guide future policies and economic recovery strategies in the face of similar challenges.

During the pandemic seen in 2020, there was a significant change in consumption patterns and the supply of products and services, resulting in inflationary pressures. Public policies implemented to deal with the crisis, such as movement restrictions and economic

stimuli, directly affected inflationary dynamics. For example, supply chain disruption has led to increases in the prices of essential products, while monetary stimulus measures such as currency printing have contributed [22] to greater liquidity and, consequently, inflation. Furthermore, external events, such as the political crisis in Europe, also influenced inflation rates. Thus, inflation in 2021 and 2022 reflects not only the effects of the pandemic, but also strongly the government policies adopted to face the crisis and other external factors that affected the global economy. Fig. 1 shows the effects of inflation in the United States, the world's largest economy, by segment during the pandemic period.

Table. 1: Comparison of Recession in Countries

Crisis	Root Cause	GDP Impact	Unemployment Impact	Inflation (CPI) Impact
1929	American stock market crash	GDP fell by around 10% in 1930 and 31 and 15% in 1932. Values only returned to normal 13 years later, in 1942	The total number of unemployed people in the United States in 1929 was 1.5 million. The number grew in the following 2 years: 4.3 and 8 million. The level of 2 million or less was only reached again in 1942.	Measurement began at the time, data is scarce. In the United States, from 1913 to 1929, the annual average was 3.5%. In the first 3 years of the 1930s, an average of 10.8%
2008	Subprime Mortgages	1.3% drop in world GDP in 2009, 4.49% increase in 2010. GDP in 2010 was higher than in 2008 in absolute values	It went from 5.4% in 2008 to 6% in 2009, only in 2018 did the indicator perform similarly to pre-crisis (5.4%)	The peak of global inflation was in 2008, at 8.95%. Among the most prominent countries, 2009 was a year of low and growing inflation until 2011, where it presented similar numbers to 2007 (4.8%)
2020 (COVID)	Coronavirus	3.1% drop in world GDP in 2020. Estimated at the beginning of 2022 that GDP 21 would increase by 5.9% and would continue to grow in 22 and 23	5.4% of unemployed in 2019 and 6.6% in 2020, a greater increase than in 2008. The forecast is that in 2023 we will still have 5.7%.	Inflation was low in 2020 (1.89%) and much higher in 2021 and 2022. Projections for 2023 are also higher than those seen in 2019 and 2020

Throughout 2021, the general inflation index showed constant evolution, and the energy index showed a strong increase, driven by events around the world. According to data from the European Central Bank (2021) [4], the lack of wind in the United Kingdom that caused windmills to stop, droughts in Brazil that led to less energy from dams and the cold winter of 2022 left the Europe with smaller oil and gas reserves, along with growing demand across the globe. This increase in energy ends up creating a cascade effect on other items that depend on production and transport, that is, it further amplifies inflationary rates. And, added to the greater volume of currencies [6], the devaluation of paper, caused general and collective inflation in the world, starting in 2021 and amplified in 2022, not least due to the political crises in Europe, involving the war between Russia and Ukraine.

Given the immediate impact on GDP in 2020 [17] and the subsequent impact on inflation as exemplified in Fig. 1, it is understood that in fact COVID-19, despite starting as a health crisis, also presented itself as a crisis economic. A strong drop in economic activity was seen on all continents, an increase in unemployment, a decrease in family income, strong financial instability of people and companies, in addition to an initial deflation, as a result of the policies applied, with the subsequent and already mentioned inflation. Furthermore, the pandemic brought with it social impacts such as increased social inequality, the bankruptcy of small businesses, overload on the

healthcare system and housing crises. As a result, countries around the world were forced to resort to economic and fiscal policies to control the impacts of crises, thus justifying an analysis of economic recovery; after all, there must be a recession for there to be a recovery.

Therefore, after a prior analysis to select significant countries, based on the size of their economy and the expressiveness of the recovery of the indicators in question, GDP, unemployment and inflation, Table 2 was created, presenting a comparison of the COVID-19 crisis, with what actions were taken for an eventual post-crisis economic recovery. Produced from data from [11], [12], [16]. [17] and [18] to facilitate relevant discussions

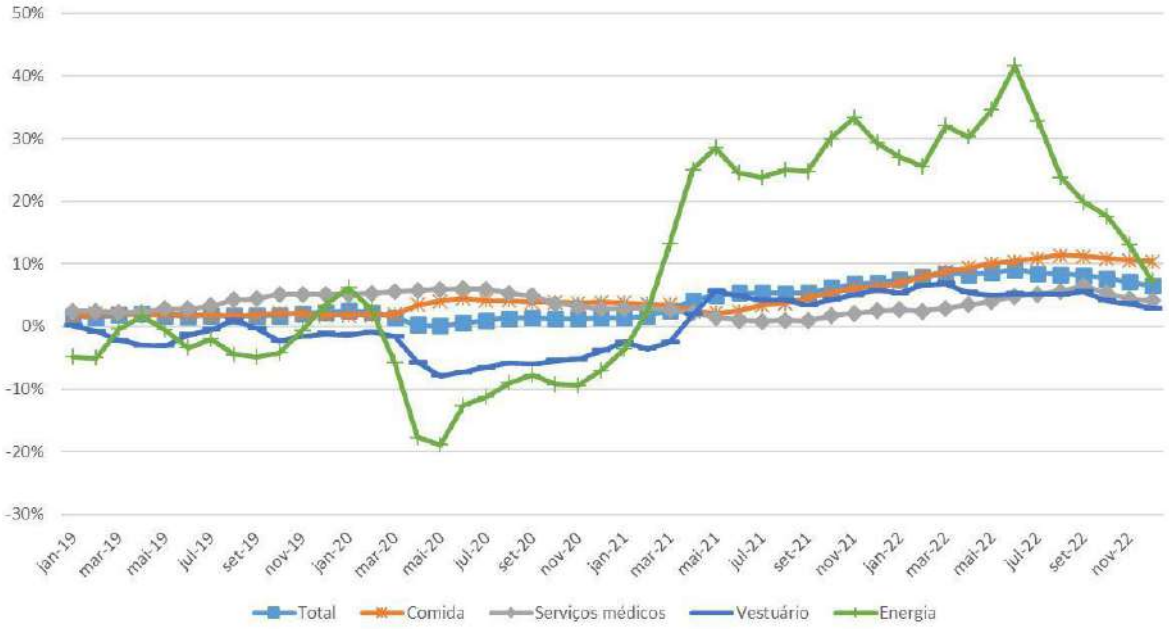

Fig. 1: Accumulated inflation – United States

Table. 2: Comparison of Recession in Countries

Crisis	Actions to mitigate impacts	GDP Impact	Unemployment Impact	Inflation Impact
Germany	Fiscal stimulus for companies; Loan guarantees; Emergency purchase program; Loans to banks for liquidity; Asset purchase program; Tax cuts.	-1.81% variation between 2019 and 2021	Unemployment peak was 6.40% (Aug/2020), 1.5% higher than in December 2019	Highest value in (Sep/22) with 10.4%, 8.6% in Dec/2022 and 1.7% in Dec/2019.
Australia	Wage subsidy for employers; Cash flow assistance; Early access to pension fund; Interest rate cut; Purchase of government bonds.	1.47% variation between 2019 and 2021	Unemployment peak was 7.50% (Jul/2020), 2.4% higher than in December 2019	Highest value in (Oct/2022) with 7.8%, 7.8% in Dec/2022 and 1.8% in Dec/2019

Brazil	Economic aid for companies and families; Credit expansion and tax postponement; Spread reduction and increased liquidity; Historic reduction in the basic interest rate; Liquidity measures for loans and banks.	0.56% variation between 2019 and 2021	Unemployment peak was 14.90% (Sep/2020), 3.8% higher than in December 2019	Highest value in (Apr/2022) with 12.13%, 5.79% in Dec/2022 and 4.3% in Dec/2019
China	Tax Relief; Subsidies; Credit support; Stimulating investment; Interest rate cuts; Quantitative Ease; Currency intervention.	10.53% of variation between 2019 and 2021	Unemployment peak was 6.20% (Feb/2020), 1.7% higher that in December 2019	Highest value in (Jul/21) with 5.4%, 1.8% in Dec/2022 and 0.8% in Dec/2019.
United States	Direct payments, loans and financing; Paid leave and benefits unemployment; Emergency Loan; Interest cut; Quantitative Ease.	2.07% of variation between 2019 and 2021	Unemployment peak was 14.70% (Apr/2020), 11.1% greater than in December 2019	Highest value in (Jun/2022) with 9.1%, 6.5% in Dec/2022 and 2.3% in Dec/2019.
Ireland	Tax relief package for businesses; More money for health and support for unemployed and low income; Fiscal measures to alleviate the burden; Interest rate reduction; Asset purchase program; Credit guarantee scheme for companies.	20.14% of variation between 2019 and 2021	Unemployment peak was 7.70% (Mar/2021), 2.9% greater than in December 2019	Highest value in (Oct/2022) with 9.2%, 8.2% in Dec/2022 and 1.3% in Dec/2019.
United Kingdom	Wage subsidy for employers and independent workers; Cash flow loans; Reduction of VTA to 5%; Cut in bank rates; Asset purchase program increased	-2.52% from variation between 2019 and 2021	Unemployment peak was 5.20% (Dec/2020), 1.4% greater than in December 2019	Highest value in (Oct/2022) with 11.1%, 10.5% in Dec/2022 and 1.3% in Dec/2019.

It is natural that, in the face of the crisis, many countries have resorted to similar economic policies, such as quantitative easing, interest rate reductions and fiscal stimulus packages. These measures were designed to stimulate aggregate demand, to provide financial support to affected businesses and households, and to prevent the recession from prolonging. However, the effectiveness of these policies varied considerably according to the implementation and economic context of each country, even if, as seen in Table 2, the policies applied were of similar ideas, the effects were seen differently in terms of GDP, inflation and unemployment, for example, nearby countries such as Ireland and the United Kingdom presented diametrically opposite GDP, respectively, 20.14% against -2.52%.

Therefore, countries like Australia and Ireland, more economically liberal countries [10], have emerged as examples of a relatively robust recovery in terms of GDP

and unemployment. These nations have managed to keep unemployment under control and minimize economic contraction, in part due to targeted investments in infrastructure and support for businesses and workers affected by the crisis. The rapid mobilization of resources and the effective implementation of stimulus policies played a crucial role in protecting the economies of these countries against the worst effects of the pandemic.

However, other countries have faced significant challenges in economic recovery. Germany and the United Kingdom, for example, recorded falls in GDP and high relative unemployment rates, reflecting the specific difficulties faced by their economies during the pandemic. Factors such as dependence on heavily impacted sectors, such as tourism and the third sector [1], contributed to the difficulties faced by these nations in the search for a sustainable economic recovery.

An interesting aspect to observe is the allocation of resources during the crisis. Brazil, for example, chose to invest much less relatively (as a percentage of the country's GDP) compared to the others, but the majority of this investment was directed directly to the needy population, with an approach of financial assistance to the population. This approach may have contributed to mitigating the negative effects of the crisis on the most vulnerable and helped to maintain social cohesion amid economic adversity, however, the lack of investment in infrastructure and programs with long-term thinking has a greater chance of, in the medium and long term, demonstrate negative impacts on the speed of economic recovery and the country's subsequent economic growth.

Table. 3: Investments made by countries

Country	Total Injected (% GDP)	Direct aid (% GDP)	Direct aid (% of total injected)
Australia	20.00%	2.50%	12.50%
Ireland	14.00%	2.00%	14.29%
United Kingdom	20.00%	3.50%	17.50%
USA	25.00%	6.00%	24.00%
Germany	16.60%	4.20%	25.30%
Brazil	9.20%	5.00%	54.35%

* China did not have its data released in a satisfactory manner to carry out the analysis.

With this less immediate thinking, countries like Ireland and Australia adopted a different strategy, investing more in infrastructure and supporting companies, aiming for a more sustainable economic recovery in the long term. This approach appears to have been effective, considering the relatively quick recovery of these countries compared to others. Table 3 presents a relationship, based on data from the IMF [12], between the percentage of investment and the percentage of direct aid to the population's pockets.

Therefore, the importance of these economic policies during periods of crisis is highlighted and how these policies can shape the recovery trajectory of each country and, although there is no single approach to dealing with an economic crisis, after all, each particularity of the population and its government, as a percentage of the nationalized economy, levels of corruption and even people's educational levels, can have a negative or positive impact, however the results suggest that investments aimed at infrastructure and support for companies can significantly contribute to a sustainable economic recovery in In the long term, that is, less populist policies in countries with more liberal economies, such as Ireland and Australia [10], present more economically optimized results.

Furthermore, it is crucial to recognize that the economic challenges posed by the pandemic do not end when the public health crisis abates. Many nations will face long-term economic consequences such as rising debt, exacerbated inequality, and structural changes in labor and consumer markets. Therefore, it is essential that governments continue to closely monitor the economic situation and implement appropriate policies to promote an inclusive and sustainable recovery.

As we move into a post-pandemic future, it is critical to learn from the experiences and lessons learned from this challenging period. This includes not only identifying the most effective policies to respond to economic crises, but also addressing underlying structural issues that can make economies more resilient to future shocks. Only through a collaborative, long-term oriented approach can we build a more stable and prosperous economic future for all.

III. CONCLUSION

Based on the post-crisis economic recovery, focusing on the COVID-19 pandemic and considering key indicators such as GDP, unemployment and inflation, implemented actions and their consequences were observed in selected countries, highlighting the effectiveness of investments in fiscal policies and flexibility in public management.

Australia and Ireland showed positive results due to investments in professional qualifications and state infrastructure. Geographically close countries, such as the

United Kingdom and Ireland, demonstrated contrasting results, with Ireland showing the highest GDP growth.

Global inflation was impacted by governments' fiscal and monetary policies, reflecting the devaluation of currencies. Countries with rapid economic recovery are at an advantage to attract investments and strengthen their infrastructure instead of resorting only to direct financial support to the population. It is worth highlighting, however, that comparisons must be based on a country's pre-pandemic and current economic potential. Brazil, for example, cannot be considered low-income just because it had high unemployment and inflation figures in the period; after all, these are indices that, in several passages in recent history, demonstrated double-digit values, that is, above 10%

Furthermore, as future work, this can serve as a bibliographical basis for future analyzes and studies, in addition to promoting political-economic discussions, highlighting, above all, the importance of a detailed analysis of Ireland and the policies applied in the country.

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