

Article

Design and Development of a Python-Based Multi-Game Desktop Application with CustomTkinter

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Abstract: The current work is a Graphical User Interface (GUI) based Game Center application developed using Python and CustomTkinter framework. The program includes a user authentication system (login and signup) that is connected to a MySQL database using the 'pymysql' module to securely manage user credentials. After the user has been successfully authenticated, he/she can access the centralised game hub which consists of three interactive games, namely, Hand Cricket, Rock Paper Scissors and Tic Tac Toe. Separate logic and user interfaces that are easy to understand are built for each game with 'CustomTkinter' which increases the visual appeal and interactivity. The Hand Cricket game is a simplified cricket match game in which the user plays against the computer with the help of random number generation. Rock Paper Scissors generates dynamic action through images and randomisation. Tic Tac Toe offers a grid - based challenge for two players with automatic win and draw detection. On the whole this project is a good example of how GUI and DB management, alongside basic game logic, can be combined into an application. It prepares the ground for building multi-game platforms and shows the potential of Python for building fun, visually stunning desktop apps.

Keywords: Graphical User Interface (GUI), Rock Paper Scissors, MySQL Database, User Authentication, Hand Cricket, Tic Tac Toe, Multi-Game Platform, Game Logic.

1. Introduction

The Game Center project is a fully desktop-based entertainment application written in Python. The goal of this project is to provide users with an interactive, aesthetically pleasing, and user-friendly gaming environment. The fast pace of software development technologies and graphical user interface frameworks has enabled developers to design complex desktop applications with better usability and better user experience [35]. Python is one of the most popular languages because of its simplicity, flexibility, extensive library support and cross-platform compatibility. Using these, the project is a combination of Python and the CustomTkinter framework to create a modern graphical interface that brings together functionality, aesthetics and performance into a single application [36]. The project showcases the integration of multiple software engineering concepts such as graphical user interface design, database connectivity, event-driven programming,

modular coding practices, and game logic implementation to create a practical and engaging desktop application [37]. The main purpose of this project is to create a common Game Center where users can play multiple old games from a single interface without the need to do individual installations or internet access [38]. Most of the casual games available today are either hosted on websites that require constant access to the internet or are distributed as standalone applications that occupy unnecessary storage space and force users to switch between programs. Such fractured access often forces users to sacrifice greater convenience and inconsistent user experiences [39]. This project aims to address these challenges by presenting multiple games in a unified platform and seamless navigation and consistent user interaction across the application. The integration of multiple games within a single desktop environment allows users to conveniently switch between different entertainment options without having to quit the application [40].

The application includes three popular classic games: Hand Cricket, Rock Paper Scissors and Tic Tac Toe. Each game has been developed separately with its own game logic but with a common graphical interface and authentication system [41]. Hand Cricket is a fun simulation of a simplified cricket match where the player is pitted against the computer by selecting numerical values corresponding to runs scored [43]. The computer generates random numbers, which makes the game unpredictable and fun. The Rock Paper Scissors module implements the traditional hand game in a graphical interface [42]. The user can play against the computer using randomly generated choices. The Tic Tac Toe module is a strategic board game in which the user can play against another player or against the computer. The application automatically detects winning combinations and draw conditions [45]. These games offer varied gameplay and illustrate programming techniques such as random number generation, conditional decision making, grid management, and event handling. And the implementation of the secure user authentication system is one of the key features of this project [46]. Unlike most beginner Python gaming projects which provide the entire access, this app has user login and signup for personalised management. To access the Game Center, users need to register an account by creating a unique username and password [47]. The credentials are securely stored in a MySQL relational database with the help of the PyMySQL module which allows the application to communicate efficiently with the back-end storage [48]. Existing users can log in via the login interface before they can access the gaming platform [44].

This authentication mechanism enhances application security and offers a personalised experience for each user. The database functionality also exposes the learners to real-world concepts such as the execution of SQL queries, database connection management, data validation, and secure storage of user information [49]. The graphical user interface represents another major strength of this project [51]. Instead of relying on conventional Tkinter widgets that often produce outdated interfaces, this application uses the CustomTkinter framework to create a modern desktop experience with attractive color schemes, customizable widgets, smooth button designs, enhanced typography, and responsive layouts [52]. The graphical components have been carefully designed to improve user interaction and navigation throughout the application [55]. Every screen, including the login page, signup form, home dashboard, and individual game interfaces, maintains a consistent visual theme that contributes to a professional software appearance. The interface is intuitive enough for users with minimal technical knowledge while remaining visually attractive to encourage continued interaction. Image processing capabilities are incorporated into the application using the Python Imaging Library (Pillow) [54]. Images significantly improve user engagement by replacing plain textual representations with colorful visual elements that better represent game objects and interface components. For example, the Rock Paper Scissors module displays graphical images corresponding to each move selected by the user and the computer, making gameplay more interactive and realistic [56]. Icons, logos, and decorative interface elements are also managed through Pillow, allowing efficient loading, resizing, and

rendering of images throughout the application [53]. These graphical enhancements improve usability while demonstrating multimedia integration within desktop software development [50].

From a software engineering perspective, the Game Center follows a modular architecture, separating functionality into independent components. Rather than implementing the entire application within a single script, each game and major feature is organized into dedicated functions and modules [57]. This modular structure simplifies program maintenance, debugging, testing, and future expansion [58]. If additional games or features need to be incorporated later, developers can extend the application without significantly modifying the existing source code [59]. Such modularity improves code readability while encouraging software reusability and adherence to good programming practices. The application is also heavily based on event-driven programming [62]. When the user clicks a button, moves the mouse, presses a key, or asks to go somewhere, a function is called that updates the interface and runs game logic [63]. The event-driven architecture makes the application reactive to the user actions, providing an interactive experience rather than a pre-determined sequence of operations [61]. All the games constantly change the interface depending on what the players do, or what the computer decides to do, or the result of the game [65]. This keeps the application responsive as it runs. Another important aspect of the project is its offline functionality [64]. Unlike many modern gaming applications that require continuous internet connectivity for authentication, advertisements, or cloud synchronization, the Game Center operates entirely as a standalone desktop application once installed. Users can enjoy uninterrupted gameplay regardless of network availability [60]. This offline feature is especially useful for educational institutions, personal computers, and environments where internet connectivity may not always be dependable [66]. Additionally, removing the need to connect to the Internet speeds up the application, reduces latency, and increases reliability overall [67]. The problem that this project addresses is the fragmentation of casual gaming platforms that are available to users today [68]. People generally have more than one application installed or visit different websites to play simple games like Hand Cricket, Rock Paper Scissors or Tic Tac Toe [69].

These platforms may include advertisements, require you to sign up online, or have an inconsistent interface design. These limitations reduce the convenience for the user and impair the gaming experience [70]. And a lot of small educational games created with the help of Python are limited only to the implementation of game mechanics, without any user authentication, database management, or professional graphical interface [71]. Consequently, they do not show the integration of a number of software engineering concepts into a single application [73]. The purpose of this project is to overcome these shortcomings by combining multiple games, secure authentication, database integration, modern graphical design and modular software architecture into a single cohesive desktop solution. The development is aimed at simplicity without losing functionality [74]. Each feature has been designed to offer a good balance between usability, efficiency and maintainability. The application has a consistent environment and users can easily register and login, select the game they want, interact with graphical controls that are intuitive and have engaging gameplay [75]. On the other side, developers get a well organised codebase that can be enhanced in the future. For example, they can add score keeping, player statistics, difficulty levels, online multiplayer, achievements, cloud syncing, and better artificial intelligence [76]. Not only a fun app, but the Game Center is also a great learning project which shows the practical use of several software development principles such as Python programming, GUI design, database integration, modularity and event driven programming [72].

Review of Literature

The successful implementation of the Game Center application is driven by several carefully defined objectives, which together contribute to the development of a complete, efficient and user-friendly desktop gaming platform. The primary aim is to create and launch a central application which will contain several mini-games in one graphical environment. The Game Center is a single platform that can host multiple games, and there is no need to download separate applications for each game [1]. The integration increases convenience, reduces software redundancy and provides a consistent interface to users across all gaming modules. It also facilitates software maintenance and future expansion via the centralised architecture, making it easier to add new games without having to modify the application's overall framework. Another important goal of the project is to implement a reliable and secure mechanism for user authentication [9]. User authentication is an important part of modern software systems which ensures that only authorised users can access the application resources [2]. The Game Center uses the PyMySQL library to access a MySQL relational database for the login and signup functionality. During registration, users are required to provide a unique username and password which are validated before being stored in the database. The login page allows existing users to authenticate themselves [4]. The credentials entered are checked against the stored credentials. This process is meant to prevent unauthorised access, while also giving users a personalised experience. The authentication system also introduces important database concepts such as table creation, SQL query execution, connection handling, data retrieval, insertion, validation and exception management [5].

A main goal of the project is to develop a graphically attractive user interface that enhances the interaction with the user. Standard Tkinter is used for the development of traditional desktop applications, which doesn't offer modern visual elements and attractive widget customisation [10]. To overcome these limitations, this project uses the CustomTkinter framework, which enhances Tkinter capabilities by providing customisable themes, rounded buttons, responsive widgets, improved colour schemes, and enhanced interface consistency. Each screen in the app has been carefully crafted for seamless transitions, easy navigation and an engaging user experience. Navigation between the authentication screens, the main dashboard and the individual game interfaces is simple and straightforward for the user, without any confusion or unnecessary complexity [11]. These design principles are good for usability and also show contemporary desktop application development techniques. Another important goal of the project is the implementation of the intelligent game logic [12]. Each game in the Game Center has its own rules of operation programmed in structured algorithms of Python. The Hand Cricket game simulates the batting and bowling interactions between the player and the computer using random number generation. Rock Paper Scissors is a game that uses conditional statements to determine winning combinations based on random selections from the computer [13]. The Tic Tac Toe game has a grid system that is structured to check the player moves, recognise the winning pattern, identify the draw condition and prevent invalid moves. These algorithms illustrate practical applications of decision structures, loops, arrays, conditional logic, and event handling in interactive software development [3].

Another important aspect reflected in the project objectives is automation. Instead of the user having to manually do things like generate the computer's moves, determine scores, determine winners, update interface, and reset the game, the app does these things automatically [14]. This kind of automation is low effort for the user and gives a fun experience of gaming. Randomisation techniques are used to ensure fairness in computer play and avoid predictable outcomes that would bore the player over repeated sessions. The Game Center also puts a strong emphasis on modular software architecture as a major development goal [15]. The application is organised in a modular way, with each module or function providing a separate functionality such as user authentication, database

operations, navigating through the interface, loading images, and executing the individual games [16]. This modular approach has many benefits including better code readability, easier debugging, easier maintenance, better reusability and scalability. Developers can modify or replace individual modules without affecting other unrelated parts of the application. These software engineering practices are extremely similar to industry standards for developing maintainable desktop applications. Another important consideration in the development of the project is scalability [17]. In the implementation there are currently only 3 games, however the architecture of the application has been created in such a way that it allows for future expansion [18].

Other games such as Snake, Sudoku, Chess, Checkers, Connect Four, Minesweeper, Memory Puzzle, or Sudoku can be added by developing separate modules to plug into the existing navigation framework. Future enhancements may also include player scoreboards, achievement badges, difficulty levels, personalised themes, cloud sync, AI opponents, online multiplayer, tournament management, and game recommendation systems. Such features can be added due to the modular design without major restructuring of the existing application [19]. The project scope is mainly focused on the development of a desktop-based gaming application for personal computers not running on the internet. It's a good offline entertainment platform where you can enjoy multiple games after successful authentication [20]. The scope includes graphical user interface design, user authentication, database integration, image processing, game logic implementation, event-driven programming, and modular software development. Together these make up the components needed to form a complete desktop application that combines entertainment and the principles of practical software engineering [21]. The graphical interface is a large part of the project scope. All the interface elements have been developed with CustomTkinter to give the application a modern desktop look and consistent navigation between the application screens [22]. Buttons, labels, entry fields, frames and images have been carefully positioned to achieve maximum usability with minimum visual clutter. Responsive layouts make it possible for users to understand how applications work without having to read lots of instructions or have technical knowledge [6].

Database management is also within the defined scope of the project. The MySQL database is the storage mechanism for user credentials, and PyMySQL is used to communicate with the database server. This integration allows us to show a real use of client-server interaction in desktop apps [23]. Database connectivity also exposes students to concepts of real world software development such as persistent data storage, executing queries, connection security and transaction management and exception handling. Image integration also extends the scope of application. The Pillow library is used to load, resize and display images throughout the user interface to improve the overall presentation quality [24]. Visual representations are much more engaging for users than simply presenting textual information [25]. Different game icons, interface backgrounds, logos, game images, etc. Looks professional and distinguishes your application from a basic python project [26]. The motivation for this project is more than just entertainment. A major motivation is the growing demand for lightweight desktop applications that are independent of internet services. While online gaming platforms are gaining popularity, many users still prefer offline games as they don't have to deal with advertisements, subscriptions, latency, or connectivity issues. The Game Center meets this need by giving instant access to lots of games, without needing external servers or a constant internet connection [27]. A further important motivation comes from the educational requirements. Students who learn Python programming often develop individual games or standalone database applications but seldom combine several technologies into a single software system [7].

This project integrates graphical interface development, relational database management, object orientated programming principles, event driven programming,

software architecture modularity, image processing and algorithm implementation in one application [28]. This integration gives you valuable hands-on experience and improves programming skills in different areas of software engineering [29]. The project also shows how creative Python can be as a desktop application development platform. Python is very tied to artificial intelligence, data science and automation, but it is a powerful language for graphical user interface (GUI) development and multimedia programming [30]. This project demonstrates the use of different libraries like CustomTkinter, Pillow, PyMySQL, and the basic concepts of Python programming to make beautiful and functional desktop applications that can be utilised for educational, recreational, and commercial purposes. Another driver is to support organised software development methodologies for students and novices [31]. This project is about writing working code as well as about software design principles such as modularity, maintainability, scalability, user experience, database normalisation, interface consistency and efficient resource utilisation [32]. These practices prepare students for larger software engineering projects and demonstrate how professional desktop applications are designed and implemented. In the end, the Game Center is both an entertainment destination and an educational tool to demonstrate modern desktop software engineering [33]. It shows how creativity, programming knowledge, graphical design, database technology and modular development can be combined to produce a practical, enjoyable and extensible application [34]. The project represents a great example of how Python programming techniques can be used to solve real-world software development challenges and offer users a reliable and enjoyable gaming experience thanks to its integrated architecture, secure authentication, attractive interface and engaging gameplay [8].

2. Materials and Methods

Existing System

In the present situation, users who are interested in playing simple games like Hand Cricket, Rock Paper Scissors or Tic Tac Toe, generally depend on multiple sources such as mobile apps, web based platforms or independent Python scripts [77]. Although these platforms offer entertainment, they have many limitations that impact the user experience and functionality (Figure 1).

2.1. Design (Er Design) And Proposed Methodology

2.1.1. Block Diagram

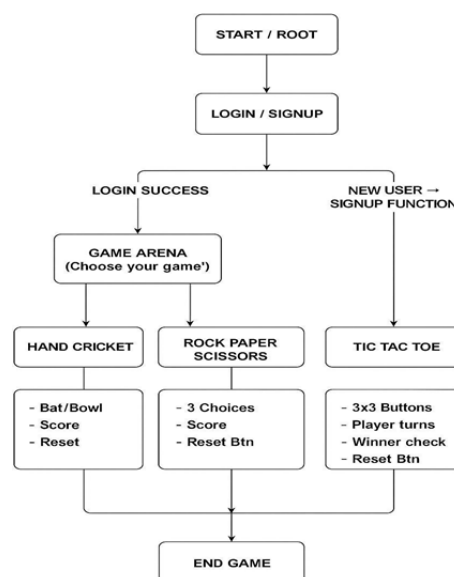


Figure 1. Flowchart of the Game Arena Application Login and Game Selection Process.

2.2. Proposed Methodology

2.2.1. System Overview

- The Game Center application is a one stop platform where users can log in or sign up and play different interactive games.
- The system combines GUI design with CustomTkinter, user authentication with MySQL, and gameplay logic into one interface.

2.3. System Components

2.3.1. Frontend (GUI Layer)

- Modern, user friendly interface designed in Custom Kinter Includes:
- Login and Signup screen
- Arena (Game Selection)
- Standalone Game Windows (Hand Cricket, Rock Paper Scissors, Tic Tac Toe)

2.3.2. Backend (Database Layer)

- Stores and manages user credentials using MySQL. Handles:
- Registration (sign up) of user
- Authentication (verification of login)

2.3.3. Game Logic Layer

- Runs the main logic for each game:
- Scoring & Random Number Generation in Hand Cricket
- Rock Paper Scissors – Work out who has won based on the choices
- Tic Tac Toe – Grid system, turn keeping and winner checking

2.4. Implementation Steps

2.4.1. Step 1: Environment Setup

Install the following libraries: customtkinter, pymysql, Pillow. Setup the mysql database siva1 with the following table:

- CREATE TABLE username_password2 (username VARCHAR (50), password VARCHAR (50);
- Set up image files for Rock, Paper, and Scissors.

2.4.2. Step 2: GUI Development

- Initialize the CustomTkinter main window.
- Add labels, text boxes, and buttons for login and game interactions.
- Create separate top-level windows (CTkToplevel) for each game.

2.4.3. Step 3: Database Integration

- Establish a MySQL connection using pymysql.
- Implement the following functions:
- Signup () – Adds new user records to the database.
- Login () – Verifies user credentials and opens the game arena.

2.4.4. Step 4: Game Design and Logic

- Hand Cricket: Players and the computer take turns scoring runs; randomization determines outcomes.
- Rock Paper Scissors: Implements classic rule-based logic between three choices.
- Tic Tac Toe: Uses a 3x3 grid array, turn-switching, and pattern checking for wins or draws.

2.4.5. Step 5: Game Arena Integration

- After a successful login, open the Arena window.
- Provide buttons to access each mini-game.
- Include reset and score display features in each game window.

2.4.6. Step 6: Testing and Debugging

- Verify user login, signup, and game transitions.
- Test gameplay functions and reset buttons.
- Handle exceptions, including invalid input and database errors.

2.5. Expected Outcome

- Smooth user authentication and registration.

- Interactive and visually appealing user interface.
- Functional mini-games with individual scoring systems.
- Consistent performance and proper error handling.

2.6. Entity Relationship Diagram

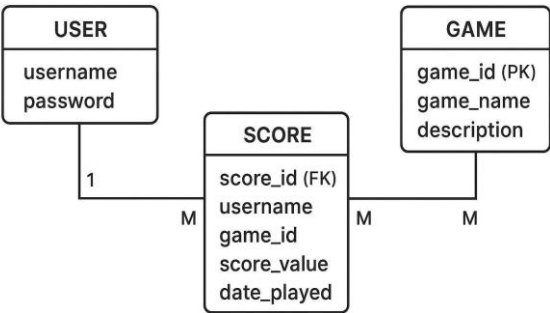


Figure 2: Entity-Relationship Diagram of User, Game, and Score Database Schema.

3. Results and Discussion

The Game Center project is important in that it combines various software development technologies into a single, simple, usable and extendable desktop application [78]. This project shows how the elements of software engineering can be combined in order to develop a full-fledged real-life application, as opposed to the traditional academic programming tasks of implementing standalone algorithms or a single graphical interface. It includes graphical user interface development, database connectivity, modular programming, image processing, event-driven paradigm and game implementation to make it useful and educational [80]. All parts have been built to work together so that users will experience smooth navigation and responsive interactions from launch to exit. One of the most useful features of the application is the authentication mechanism. It mimics real-world software requirements where personalised access and secure data management are essential [81]. The MySQL database holds individual credentials for each registered user, which are used for secure authentication before access to the gaming platform is provided. Validation process prevents duplicate usernames , checks user inputs and maintains the consistency of data in the database [82]. Additionally, reliability is increased through exception handling routines that detect invalid inputs, failed database connections and unexpected execution errors to prevent application crashes [83]. The implementation demonstrates some basic cybersecurity practices and familiarises you with authentication flows used in many modern desktop and web apps (Figure 2) [79].

The database integration gives an important functional value to the application apart from mere gameplay [84]. Game Center uses PyMySQL to create a stable connection between Python and MySQL to save and read users’ information in an organised manner [85]. This interaction demonstrates real-world database operations such as inserting, selecting, validating, establishing connections and executing transactions [86]. A relational database is used instead of local text files which provides better scalability, data organization and security [88]. Additionally, the database structure is designed to support future enhancements, including the storage of player statistics, score history, game achievements, login activity, and personalised recommendations based on user preferences [89]. The use of independent game modules also shows effective software engineering practices. Every game has been created as an independent functional unit with clear responsibilities [90]. This means that developers can update one module without affecting the others. This separation of concerns makes the software easier to maintain and makes future updates to the software easier. The Hand Cricket module deals with probability based game play which is achieved by random number generation and score

calculations. The Rock Paper Scissors module covers conditional decision making and visual feedback via image-based selection. Tic Tac Toe module implements game management using a matrix, game turn validation, win detection and draw evaluation. Together, these games expose developers to a wide variety of programming concepts and provide users with a diverse set of entertainment choices [87].

The graphical interface, one of the project's strongest points, still greatly increases user satisfaction and accessibility. CustomTkinter allows applications to overcome many visual limitations of the traditional Tkinter interfaces, with customisable widgets, modern layouts, rounded controls, improved typography and attractive colour themes [92]. All interfaces have been created with consistency in mind, so no matter which game is selected, navigation is intuitive. Descriptive labels, responsive buttons, structured layouts and visually balanced components reduce cognitive load and allow users from different technical backgrounds to interact with the software comfortably [93]. This results in an effective balance between functionality and aesthetics in the application. The Game Center will have a more impressive visual appeal with image integration using the Pillow library. The use of graphical elements adds to the realism and fun of gameplay instead of text based output [94]. Images of game symbols, interface icons, logos and decorative elements improve the professional appearance of the software and help users understand the various components of the application. Good resizing, optimisation and rendering of images will make sure that the interface is still responsive and doesn't use up too much memory [95]. These multimedia facilities show how graphical resources can be integrated effectively into desktop software development. Another big plus of the application is its offline capability [91].

The Game Center does not require the internet, online authentication, advertisements or cloud services like many commercial gaming platforms. Once installed it is a stand-alone application. The application can be run by users, and they can log in and play without needing a network connection. This offline capability makes the software ideal for educational institutions, laboratories, homes, libraries and remote locations where reliable Internet connectivity may not always be available [96]. It also removes the problems of network latency, server downtime, subscription fees and privacy issues that are associated with online gaming platforms [97]. The project has also served as a very good educational resource for students in the fields of computer science, software engineering and information technology. In its development, learners gain hands-on experience in Python programming, graphical interface design, relational database management, event-driven programming, modular software architecture, random number generation, image processing, exception handling, and structured application development. Rather than learning these concepts separately in isolated examples, students see how they combine in a full software system. This extensive exposure will better equip the learners for larger industrial software projects where integration of multiple technologies is a must (Figure 3).

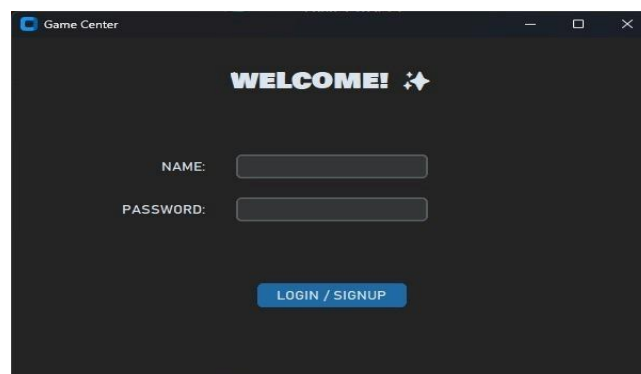


Figure 3. User Login and Signup Interface of the Game Center Application.

From a software quality point of view, the application focuses on maintainability, scalability, reliability and usability. The code is modularly organised and the functional separation makes it maintainable. The architecture is scalable, because it is flexible enough to allow other games and features to be added in the future with minimal modification of the existing parts. Reliability: This comes from exception handling, input validation, secure database operations, and consistent event management. Intuitive navigation, attractive interface design and simple user interaction improve usability. All these features together help in developing a reliable software application which can be used for both educational as well as recreational purposes. The Game Center also has a lot of options for future enhancements. One extension could be to store player scores in a database so that users can track their performance over time in the games. Players could be ranked on leaderboards according to points scored, encouraging friendly competition between users. Achievement badges, reward systems and gaming milestones can further improve user engagement and motivation. The overall user experience could be improved by adding more personalisation features like custom themes, profile pictures, and game preferences. Another promising direction for future development is provided by artificial intelligence techniques. Instead of relying on a computer's randomness, you could incorporate either machine learning algorithms or heuristic search techniques. This would allow you to have adaptive opponents that change their difficulty based on the player's skill. This would greatly enhance user engagement with the game while at the same time introducing more complex computational ideas into the application (Figure 4).



Figure 4: Tic Tac Toe Game Win State.

The future holds exciting possibilities for cloud integration and online multiplayer functionality. This is currently implemented for offline use, but optional cloud sync could be added to allow users to take their gaming progress from one device to another. Online multiplayer support would allow friends to compete remotely while keeping secure authentication and synchronised gameplay. With these improvements, the application would become more of a complete gaming platform rather than a collection of desktop games. It is also worth noting that cross platform compatibility will be important for future versions. Although Python is cross-platform, packaging the application for Windows, Linux and macOS using tools like PyInstaller or cx_Freeze would make it more accessible to a wider user community. The application can also be ported to the Android and iOS operating systems using frameworks such as Kivy for mobile versions. Future versions might also include security improvements. Storing the password as plain-text is bad, better to encrypt passwords with a hashing algorithm like bcrypt or SHA-256. Further enhancing user account security could be achieved by incorporating advanced security measures

such as password recovery, account lockout after multiple failed login attempts, email verification, and multi-factor authentication.

To sum up, the Game Center project is an example of the ability of Python to construct a contemporary desktop entertainment platform that combines graphical user interface development, secure user authentication, relational database handling, multimedia processing, and interactive game creation in a single software package. This project is an example of how creativity can be applied into basic software engineering principles to create an application that is technically sound and fun to use. Apart from entertainment, the Game Center is a complete educational model which stresses the importance of modular programming, database integration, graphical interface design, event driven architecture, and software development maintainability. Its scalable architecture allows for future improvements to be integrated efficiently, making the application evolve into an even more sophisticated gaming platform. So, this project accomplishes its goal of creating a centralised desktop Game Center and additionally shows how Python is a great programming language to develop useful, user friendly and extensible desktop applications that combine technical excellence with compelling user experiences.

4. Conclusion

The Game Center project is an interactive desktop application that features several mini-games like Hand Cricket, Rock Paper Scissors and Tic Tac Toe. It delivers a sleek, modern user experience with CustomTkinter for the UI and MySQL for secure user authentication. The project demonstrates the potential of Python for the creation of a modular, scalable and user-friendly gaming platform. All modules have been developed with clarity and separation of concerns in mind to make it easy to add new games or features in the future without major changes to the system. This system overcomes the limitations of existing applications (single game) by providing a unified platform, a secure login system and engaging gameplay in an offline environment. Randomisation also makes the outcome fair and replayability possible, keeping the users hooked. In summary, the project achieves its goals of delivering an enjoyable gaming experience, enhancing logical thinking skills, and showcasing the practical application of GUI programming and database integration within Python.

REFERENCES

- [1] T. V. Hai, "Maintaining life insurance contracts of joint commercial banks with insurance links," in *Proceedings of the Eighth International Conference on Information System Design and Intelligent Applications*, Singapore: Springer Nature Singapore, 2025, pp. 131–141.
- [2] T. V. Hai, "Factors affecting short-term solvency of securities companies: The case of Vietnam," *Webology*, vol. 18, Special Issue 5, pp. 393–404, 2021.
- [3] S. Akram and Z. Pervaiz, "Estimation of inequality of opportunities across countries: a multidimensional approach," *Stud. Econ. Econometrics*, vol. 48, no. 1, pp. 18–41, 2024.
- [4] S. Akram and Z. Pervaiz, "The Role of Institutions and Social Inclusion in Trust Building," *Qual. Quant.*, vol. 58, pp. 3887–3903, 2024.
- [5] S. Akram and Z. Pervaiz, "Assessing Inequality of Opportunities for Child Well-being in Pakistan," *Child Ind. Res.*, 2025.
- [6] S. Akram, F. Zahid, and Z. Pervaiz, "Socioeconomic determinants of early childhood development: evidence from Pakistan," *J. Health Popul. Nutr.*, vol. 43, no. 1, p. 70, 2024.
- [7] S. Akram, M. U. Hassan, and M. F. Shahzad, "Factors Fuelling the Persistence of Child Labour: Evidence from Pakistan," *Child Ind. Res.*, vol. 17, no. 4, pp. 1771–1790, 2024.

- [8] S. Akram, M. Raashid, M. Usman, S. Shahzad, and S. Zareen, "Correlates of Low Birth Weight and Effectiveness of Kangaroo Mother Care for its Management: Lessons Learned from A Tertiary Care Hospital of Lahore, Pakistan," *J. Educ. Soc. Stud.*, vol. 5, no. 3, pp. 213–220, 2024.
- [9] S. Akram, Z. Pervaiz, and A. R. Chaudhary, "The Impact of Income Inequality and Intergenerational Mobility on Human Development: An empirical evidence from Pakistan," *Int. J. Disaster Recovery Bus. Contin.*, vol. 12, no. 1, pp. 263–268, 2021.
- [10] S. Akram, "Bridging the gap: understanding out-of-school children in Pakistan," *Vulnerable Child Youth Stud.*, vol. 19, no. 3, pp. 454–469, 2024.
- [11] A. Hoti and A. Dermaku, "Corporate governance in the banking industry of Kosovo: does board size and board independence matter?" *International Journal of Finance & Banking Studies*, vol. 7, no. 3, pp. 20–34, 2018.
- [12] D. Qehaja, F. Zeka, and A. Hoti, "The effect of foreign direct investments on trade balance in southeast Europe during the period 2000–2018," *International Journal of Applied Economics, Finance and Accounting*, vol. 13, no. 1, pp. 29–39, 2022.
- [13] E. Perjuci and A. H. O. Hoti, "The effects of international financial reporting standards implementation on the financial performance and position of businesses in developing countries: Evidence from Kosovo," *International Journal of Applied Economics, Finance and Accounting*, vol. 13, no. 1, pp. 1–9, 2022.
- [14] H. Hoti and L. S. Sopa, "Compliance with International Standards on Auditing (ISAs): Evidence from Kosovo for the Financial Reporting Period 2015–2019," *Finance: Theory and Practice*, vol. 26, no. 2, pp. 219–230, 2022.
- [15] R. K. Dahal, "Customer satisfaction in Nepalese cellular networks," *Tribhuvan University Journal*, vol. 33, no. 2, pp. 59–72, 2019.
- [16] R. K. Dahal, "Contemporary management accounting techniques and organizational performance," *Pravaha*, vol. 26, no. 1, pp. 177–185, 2020.
- [17] R. K. Dahal, "Assessing social and environmental performance," *Academy of Accounting and Financial Studies Journal*, vol. 25, no. 6, pp. 1–9, 2021.
- [18] R. K. Dahal, "Performance score as a measure of organizational effectiveness," *Pravaha*, vol. 27, no. 1, pp. 131–138, 2021.
- [19] R. K. Dahal, "Customers' perspectives on the Nepalese cellular telecommunications services' technological and innovation capabilities," *International Journal of Social Sciences and Management*, vol. 9, no. 1, pp. 41–47, 2022.
- [20] A. Muthulakshmi, J. Tamilselvi, and S. S. Hameed, "Moderating effects of challenges on self-efficacy and satisfaction of women street vendors," *Int. J. Electron. Finance*, vol. 13, no. 3, pp. 386–402, 2024.
- [21] T. Arumugam, S. S. Hameed, J. M. Ehya, V. Kadiresan, and R. Krishnaraj, "Impact of Artificial Intelligence on Customer Journey Mapping and Experience Design," in *Optimizing Intelligent Systems for Cross-Industry Application*, pp. 121–136, IGI Global, 2024.
- [22] K. Adivigneshwaran, J. Arun, M.S. O. Akash, R. Regin, R.L. Shyja, and R. Balku, "CampusConnect: A Data-Driven Web Framework for Smart Campus Operations Management," *Ale Journal of Sustainable Intelligent System Applications*, vol.1, no.1, pp. 1–15, 2026.
- [23] B. R. S. Sri, R. S. J. B. David, B. Sowmya, R. Regin, K. Senthamilselvan, and P. R. Christodoss, "AI-Driven Student Performance Prediction Using Behavioral, Academic and Lifestyle Analytics," *Ale Journal of Sustainable Intelligent System Applications*, vol. 1, no. 1, pp. 16–34, 2026.
- [24] J. A. Jeba, S. R. Bose, O. J. Singh, R. Regin, R. Jesfer, and J. A. Al-Mohamad, "Multilingual NLP and Voice-Based System for Predicting Scheme Eligibility and Providing Guidance," *Ale Journal of Sustainable Intelligent System Applications*, vol. 1, no. 1, pp. 35–47, 2026.
- [25] J. Ramachandran, "Autonomous Cloud Engineering Mechanism for Elastic Service Optimization in AI Integrated Enterprise Platforms," *Ale Journal of Sustainable Intelligent System Applications*, vol. 1, no. 1, pp. 48–58, 2026.
- [26] D. R. Janardhana, K. Shivanna, M. G. Shukur, C. P. Vijay, H. R. Mahalingegowda, and H. V. Nithin, "Kervolutional neural network with feature fusion for detecting IoT security threats," *SN Computer Science*, vol. 6, no. 8, p. 979, 2025.
- [27] A. Rautaray, "Intelligent adaptive authentication for zero-trust microservice architectures using AI-driven behavioral analytics," *Journal of Artificial Intelligence and Robotics*, vol. 3, no. 1, pp. 1–11, 2026.
- [28] A. Rautaray, "Centralized orchestration for high-frequency agent-to-agent negotiations: The Puppeteer Pattern," *International Journal of Research on Multidisciplinary Studies*, vol. 1, no. 5, pp. 135–152, 2026.
- [29] A. Rautaray, "Serverless Resilience Fabric for Multi-Region Microservices Under Burst Traffic and Partial Failures," *AVE Trends in Intelligent Computing Systems*, vol. 3, no. 2, pp. 68–76, 2026.

- [30] A. Marks and Y. Rezgui, "Security awareness in virtual communities: The case of non-located academic research collaborations," in *Collaborative Networks for a Sustainable World*, L. M. Camarinha-Matos, X. Boucher, and H. Afsarmanesh, Eds., IFIP Advances in Information and Communication Technology, vol. 336. Berlin, Germany: Springer, 2010, pp. 471–478.
- [31] A. Marks and Y. Rezgui, "Chief information officer profile in higher education," in *Proc. 12th International Conference on Enterprise Information Systems (ICEIS 2010)*, Jun. 2010, pp. 215–221.
- [32] A. Marks and Y. Rezgui, "Sustainable construction ontology development using information retrieval techniques," presented at the American Society of Civil Engineers (ASCE) International Workshop on Computing in Civil Engineering, Miami, FL, USA, Jun. 2011.
- [33] A. Marks, K. Rietsema, and M. AL-Ali, "Landside management information systems," *Intelligent Information Systems*, vol. 7, no. 3, pp. 45–56, 2015.
- [34] A. Marks, K. Rietsema, and M. AL-Ali, "Learning management systems: A shift toward learning and academic analytics," *International Journal of Emerging Technologies in Learning*, vol. 11, no. 4, pp. 77–82, 2016. doi: 10.3991/ijet.v11i04.5410.
- [35] A. Marks, K. Rietsema, and M. AL-Ali, "Learning management systems," presented at the NACADA International Conference, Dubai, UAE, Feb. 2016.
- [36] A. Marks, K. Rietsema, and A. Hudson, "Airport information systems—Airside management information systems," in *Proc. 20th Annual International Conference on Industry, Engineering, and Management Systems (IEMS)*, Mar. 2014, pp. 112–120.
- [37] A. Marks, I. Wilson, and H. Alhajri, "Systems development methodologies in Oman," in *Proc. International Conference on Business and Information (BAI 2012)*, Sapporo, Japan, Jul. 2012.
- [38] A. Marks and Y. Rezgui, "Information security awareness in higher education: An exploratory study," *Computers & Security*, vol. 27, nos. 7–8, pp. 241–253, 2008.
- [39] A. Marks and Y. Rezgui, "A comparative study of information security awareness in higher education based on the concept of design theorizing," in *Proc. 2009 IEEE International Conference on Engineering Management and Service Sciences (ICEMS 2009)*, Beijing, China, Sep. 2009, pp. 1–5.
- [40] A. Marks and K. Rietsema, "E-group collaboration learning tools in higher education systems," in *Proc. International Conference on Mechanical, Industrial, and Manufacturing Engineering (MIME 2011)*, Jan. 2011, pp. 88–93.
- [41] A. Marks and K. Rietsema, "Airside management information systems," *Intelligent Information Systems*, vol. 6, no. 2, pp. 77–88, 2014.
- [42] M. AL-Ali and A. Marks, "A digital maturity model for the education enterprise," *Perspectives: Policy and Practice in Higher Education*, vol. 25, no. 3, pp. 98–105, 2021.
- [43] J. B. R. Peñaherrera, K. M. T. Diaz, and A. Marks, "Fusion of forensic analysis of mobile devices: Integrating multi-criteria decision methods and case study insights," *Fusion: Practice and Applications*, vol. 16, no. 2, pp. 32–42, 2024.
- [44] M. Radi, A. A. Alwan, A. Z. Abualkashik, A. Marks, and Y. Gulzar, "Efficient and cost-effective service broker policy based on user priority in VIKOR for cloud computing," *The Scientific Journal of King Faisal University: Basic and Applied Sciences*, vol. 23, no. 1, pp. 1–8, 2022.
- [45] Y. Rezgui, A. Marks, I. Wilson, and H. Alhajri, "Developing an ISDM adoption decision model using Delphi and AHP," *Arabian Journal for Science and Engineering*, vol. 37, no. 8, pp. 2273–2285, 2012.
- [46] Y. Rezgui, A. Marks, I. Wilson, and H. Alhajri, "Using Delphi and AHP in ISDM," in *Proc. PICMET '12: Technology Management for Emerging Technologies*, Vancouver, BC, Canada, Jul. 2012, pp. 1422–1431.
- [47] C. Vorakulpipat, A. Marks, and Y. Rezgui, "Security and privacy issues in social networking sites from user's viewpoint," in *Proc. PICMET '11: Technology Management in the Energy-Smart World*, Portland, OR, USA, Jul. 2011, pp. 1–8.
- [48] A. Marks, F. Akhter, and S. Al-Naimy, "Software requirements in globalized higher education," in *Proc. 2010 3rd International Conference on Education Technology and Training (ETT)*, Nov. 2010, pp. 203–207.
- [49] G. C. Vegineni, "Sustainable tech development: Integrating AI, XR, and CI/CD pipelines for a greener future," in *Exploring the Impact of Extended Reality (XR) Technologies on Promoting Environmental Sustainability*, S. K. Gupta, N. Maurya, D. N. Le, and T. Mzili, Eds., vol. 38. Cham, Switzerland: Springer, 2025.

- [50] M. M. Reddy Chinthala and M. Kalloji, "Policy-Oriented Zero Trust Microsegmentation for East-West Traffic Governance in Hybrid Cloud Architectures," 2025 6th International Conference on Smart Electronics and Communication (ICOSEC). IEEE, pp. 1330–1335, Sep. 24, 2025.
- [51] M. M. R. Chinthala, H. Apuri, and K. Bitra, "Behaviour-Aware Hybrid Deep Networks for Detecting Zero-Day and Ransomware Threats," *IJITEE*, vol. 15, no. 5, pp. 1–10, Apr. 2026.
- [52] H. Pandian, "AI-based capacity forecasting models for elastic cloud and hybrid enterprise systems," *Journal of Information Systems Engineering and Management*, vol. 10, no. 63s, pp. 1648–1658, Dec. 2025.
- [53] H. Pandian, "AI-driven predictive performance bottleneck detection in mission-critical financial systems," *Journal of Computational Analysis and Applications*, vol. 30, no. 2, pp. 1019–1033, Mar. 2022.
- [54] H. Pandian, "Architectural optimization techniques for high-volume batch processing in Hadoop ecosystems," *International Journal of Intelligent Systems and Applications in Engineering*, vol. 8, no. 4, pp. 428–439, Dec. 2020.
- [55] H. Pandian, "Embedding performance engineering into CI/CD pipelines for regulated financial systems," *Journal of Computational Analysis and Applications*, vol. 33, no. 8, pp. 7892–7910, Dec. 2024.
- [56] H. Pandian, "Performance engineering as a first-class cybersecurity control," in *Proc. International Conference on Cyber Security, IoT, Data & Information Technology*, vol. 459, pp. 1–12, Jun. 2024.
- [57] H. Pandian, "Performance-driven development (PDD): A new software engineering paradigm," *International Journal on Recent and Innovation Trends in Computing and Communication*, vol. 9, no. 12, pp. 278–286, Dec. 2021.
- [58] H. Pandian, "Quantifying business risk and financial loss from performance failures in enterprise systems," in *Proc. International Conference on Computer Science, Engineering and Applications*, vol. 978, pp. 160–170, Jul. 2021.
- [59] H. Pandian, "Self-healing performance architectures for large-scale banking and payment platforms," *International Journal of Intelligent Systems and Applications in Engineering*, vol. 11, no. 11s, pp. 1019–1029, Dec. 2023.
- [60] H. Pandian, "Unified observability framework for enterprise performance, capacity, and reliability," *Journal of Electrical Systems*, vol. 14, no. 4, pp. 96–106, Apr. 2018.
- [61] H. Pandian, "Workload characterization models for distributed enterprise systems," *International Journal on Recent and Innovation Trends in Computing and Communication*, vol. 7, no. 12, 2019.
- [62] V. R. Anumolu and B. C. C. Marella, "Maximizing ROI: The intersection of productivity, generative AI, and social equity," in *Advancing Social Equity through Accessible Green Innovation*. Hershey, PA, USA: IGI Global Scientific Publishing, 2025, pp. 373–386.
- [63] B. C. C. Marella, "Streamlining Big Data Processing with Serverless Architectures for Efficient Analysis," *FMDB Transactions on Sustainable Intelligent Networks*, vol. 1, no. 4, pp. 242–251, Dec. 14, 2024.
- [64] B. C. C. Marella, "AI and XR in Supply Chain: Revolutionizing Sustainable Practices for a Better Tomorrow," in *Exploring the Impact of Extended Reality (XR) Technologies on Promoting Environmental Sustainability*. Cham, Switzerland: Springer Nature Switzerland, 2025, pp. 83–98.
- [65] H. Apuri and C. Yepuri, "Design of multi-agent autonomous workflow systems using agentic AI frameworks," in *Proc. IEEE Int. Conf. Advances in Urban Computing (ICAUC)*, 2026.
- [66] H. Apuri, M. Aurangabadkar, S. Goel, M. M. R. Chinthala, and C. Yepuri, "Advancing infrastructure-as-code resilience through generative AI agents for predictive remediation and autonomous security enforcement," *Int. J. Engineering and Advanced Technology (IJEAT)*, vol. 15, no. 4, Mar. 2026.
- [67] H. Apuri et al., "Self-healing infrastructure: Autonomous LLM agents for real-time remediation of configuration drift and security misconfigurations in IaC deployments," *Int. J. Innovative Technology and Exploring Engineering (IJITEE)*, vol. 15, no. 4, Mar. 2026.
- [68] G. C. Vegineni, "Intelligent UI designs for state government applications: Fostering inclusion without AI and ML," *J. Adv. Develop. Res.*, vol. 13, no. 1, pp. 1–13, 2022.
- [69] G. C. Vegineni, "Real-time performance optimization in modern UI applications," in *Proc. 3rd Int. Conf. Intelligent Cyber Physical Systems and Internet of Things (ICoICI)*, Coimbatore, India, 2025, pp. 528–533.
- [70] G. C. Vegineni and V. R. Anumolu, "Sustainable supply chain practices: A teaching framework with data science," in *Integrating AI and Sustainability in Technical and Vocational Education and Training (TVET)*, A. S. Azar, S. K. Gupta, H. Taherdoost, and F. Alhamaty, Eds. USA: IGI Global Scientific Publishing, 2025, pp. 245–262.

- [71] G. C. Vegineni, "Exploring anomalies in dark web activities for automated threat identification," *FMDB Trans. Sustainable Comput. Syst.*, vol. 2, no. 4, pp. 189–200, 2024.
- [72] A. Rautaray, "Human-centric system architecture: Decentralized decision-making to eliminate architectural bottlenecks," *International Journal of Drug Delivery Technology*, vol. 16, no. 22S, pp. 815–824, 2026.
- [73] K. M. M. Minn, H. H. K. Tin, M. Sakthivanitha, J. A. Jenifer, and I. M. Chrisostomo, "Machine Learning and Mathematical Modeling for Pattern Recognition in Large-Scale Numerical and Time-Series Datasets," *Ale Journal of Sustainable Intelligent System Applications*, vol. 1, no. 1, pp. 59–67, 2026.
- [74] A. G. García, R. Regin, E. D. Saminathan, S. N. Haq, R. Darshan, and A. T. A. Christus, "MedScope AI: A Multimodal Deep Learning Framework for Medical Diagnosis and Risk Prediction," *Ale Journal of Sustainable Intelligent Informatics*, vol. 1, no. 1, pp. 1–15, 2026.
- [75] S. Venkatesan, N. Akshay, M. Simer, J. S. Sundar, and C. B. Viswanathan, "GramHealth Lite: An AI-Powered Offline-First PWA for Smart Rural Healthcare Management," *Ale Journal of Sustainable Intelligent Informatics*, vol. 1, no. 1, pp. 16–35, 2026.
- [76] A. Sugadev, T. Yuvaprasath, J. P. Hemanaath, T. Shynnu, and M. Paslavskiy, "Automated Crop Disease Detection and Fertilizer Recommendation System," *Ale Journal of Sustainable Intelligent Informatics*, vol. 1, no. 1, pp. 36–49, 2026.
- [77] V. Ellappan, S. Tamilarasi, M. Nishanth, S. Vinothkumar, and A. Marks, "Machine Learning-Based Classification and Prediction Framework for Early Disease Detection in Healthcare: A Comparative Study," *Ale Journal of Sustainable Intelligent Informatics*, vol. 1, no. 1, pp. 50–60, 2026.
- [78] S. A. Vidot, J. A. Jeba, S. R. Bose, R. Regin, and P. Paramasivan, "Deep Transfer Learning-Based Emotion Recognition for Autistic Children," *Ale Journal of Sustainable Intelligent Informatics*, vol. 1, no. 1, pp. 61–72, 2026.
- [79] V. Kadiresan, S. S. Hameed, and B. Subramaniam, "Empathizing the Effect of Mobile Coupon Promotions on Social Shopping Behaviour," *FMDB Trans. Sustain. Hum. Soc.*, vol. 1, no. 1, pp. 30–38, 2024.
- [80] T. Arumugam, S. Hameed, J. M. Ehya, R. Krishnaraj, and S. Subbulakshmi, "Empowering Distributors by Leveraging Consumer Tenacity With Advanced Marketing Intelligence Systems and Intelligent Process Automation," in *Advancements in Intelligent Process Automation*, pp. 459–480, IGI Global, 2025.
- [81] D. B. Acharya, B. Divya, and K. Kuppan, "Explainable and fair AI: Balancing performance in financial and real estate machine learning models," *IEEE Access*, vol. 12, no. 10, pp. 154022–154034, 2024.
- [82] K. Kuppan, D. B. Acharya, and B. Divya, "Foundational AI in insurance and real estate: A survey of applications, challenges, and future directions," *IEEE Access*, vol. 12, no. 12, pp. 181282–181302, 2024.
- [83] D. B. Acharya, K. Kuppan and B. Divya, "Agentic AI: Autonomous Intelligence for Complex Goals—A Comprehensive Survey," in *IEEE Access*, vol. 13, no. 1, pp. 18912–18936, 2025.
- [84] A. Palakurti and D. Kodi, "Building intelligent systems with Python: An AI and ML journey for social good," in *Advances in Environmental Engineering and Green Technologies*, IGI Global, 2025, pp. 77–92.
- [85] D. Kodi, "Data Transformation and Integration: Leveraging Talend for Enterprise Solutions," *Int. J. Innov. Res. Sci. Eng. Technol.*, vol. 13, no. 9, p. 13, Sep. 2024.
- [86] D. Kodi, "Performance and Cost Efficiency of Snowflake on AWS Cloud for Big Data Workloads," *Int. J. Innov. Res. Comput. Commun. Eng.*, vol. 12, no. 6, p. 14, Jun. 2024.
- [87] G. V. Vasudeva, B. Gururaj, P. Y. Mallikarjun, N. M. Lutimath, and T. R. Kulkarni, "CMOS comparator design using 90 nm technology," [Journal Name], vol. 6, pp. 291–297, 2024.
- [88] G. Vasudeva, P. Y. Mallikarjun, M. Jatkar, T. R. Kulkarni, R. R. Kulkarni, B. Gururaj, and M. P. Tejas, "Design of OPAMP based on 22 nm FinFET technology," in *Proc. Fifth Int. Conf. Trends in Computational and Cognitive Engineering*, Springer, 2025, pp. 371–382.
- [89] G. Vasudeva, P. Y. Mallikarjun, S. Mahadev, T. R. Kulkarni, B. Gururaj, M. H. K. M., and J. Abhishek, "Design and development of UART communication over RSA encryption," in *Proc. 2025 Int. Conf. Electrical and Computer Engineering Researches (ICECER)*, 2025, pp. 1–6.
- [90] G. Vasudeva, P. Y. Mallikarjun, T. R. Kulkarni, M. Bhuvan, K. C. Gowthami, and N. Nidhi, "Design and optimisation of 3-bit flash ADC with low power double tail comparator," in *Engineering Science and Technology: Innovations for the Future*, 1st ed., CRC Press, 2025.
- [91] J. D. Lakshmi and P. Y. Mallikarjun, "Design of virtual-real software-defined network for cloud," in *Intelligent Computing and Networking*, Springer, 2023, pp. 367–376.
- [92] M. Jatkar and P. Y. Mallikarjun, "Optimized Cu/Fe doped boron nitride nanoribbons as nanoscale interconnect: DFT investigation," *Materials Science in Semiconductor Processing*, vol. 186, 2025, Art. no. 109050.

- [93] P. Y. Mallikarjun and A. Takele, "Parallel transmission strategy for channel sensing mechanism in cognitive radio networks," Authorea, 2023.
- [94] P. Y. Mallikarjun and Y. S. Kumarswamy, "Analysis of power transfer modeling for three-dimensional silicon chips using ThSV technologies," in Proc. 2018 IEEE Int. Conf. System, Computation, Automation and Networking (ICSCAN), Pondicherry, India, 2018, pp. 1–4.
- [95] P. Y. Mallikarjun and Y. S. Kumarswamy, "ThSV-based three-dimensional device to optimize low energy and reliable timer using MNM technique," in Proc. 2018 3rd IEEE Int. Conf. Recent Trends in Electronics, Information & Communication Technology (RTEICT), Bangalore, India, 2018, pp. 2072–2077.
- [96] P. Y. Mallikarjun, D. N. Rame Gowda, J. K. Trisha, M. Varshini, P. S. Shetty et al., "Atomistic insights into aluminium–boron nitride nanolayered interconnects for high-performance VLSI systems," *Computers, Materials & Continua*, vol. 86, no. 3, 2026.
- [97] P. Y. Mallikarjun, K. H. Dekate, G. N. Rama Devi, A. K. Koshariya, R. Sagar, and Nikhilesh, "Factors influencing economic growth of online food ordering and delivery applications during COVID-19," in Proc. Int. Virtual Conf. Newer Trends and Innovation in Nanotechnology Materials Science and Technology, vol. 12, no. 1, 2021, pp. 242–249.