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SPECIALIZED GAME COMPUTER SYSTEM BASED ON ARDUINO UNO

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In this work a specialized game system based on the Arduino Uno microcontroller was designed. The concept of the indie project was developed, and the implementation in the form of interacting modules within the framework of a single system was also presented. The system consists of three interfaces that interact with each other and can be expanded in the future. The project has all the necessary characteristics of a computer system, which are divided into several sections. Necessary accompanying documentation with a detailed description of capabilities, characteristics of the system, etc., has been created. The developed concept, as well as the possibility of its comparison with existing developments, allow to determine its advantages, disadvantages and potential areas of improvement. Further implementation helped to better appreciate all stages of game development, as they were closer to reality.

Key words: indie-development, AAA-project, game controller, game concept.

Introduction. In recent years, the unprecedented growth of computer technology has revolutionized various aspects of human life, including entertainment and gaming. One remarkable field that has seen significant advancement is the design and development of specialized game computer systems [1,2]. These systems cater to a diverse range of gaming enthusiasts, offering unique experiences and immersive gameplay.

For many, the world of games becomes a communication bridge and possibly the only way to interact with other people. Furthermore, computer games allow for faster and better perception of new information and improve coordination of movements. Many gaming projects are used for educational purposes [3-5]. The results of new studies increasingly support the significant benefits of games, such as increased gray matter and improved brain activity, among others. Emerging technologies such as virtual reality represent exciting new

opportunities not only for the gaming sector, but for different simulators (medic, military, engineering, etc.).

However, it cannot be claimed that games are solely a positive factor. It is evident that everything depends on the individual, the environment, the time allocated to gaming, and, of course, the purpose behind playing them.

Game development is a complex process that involves several stages [6-8]. In general, they can be categorized into several steps, starting with the design phase (generating ideas, choosing the genre, theme, and storyline, etc.). The testing phase is obviously a crucial point (closed, open, etc.). The industry involves many professionals with different roles, ranging from programmers who write code to managers, graphics specialists, and composers. Indie projects refer to video games that are created without the involvement of major publishers. Typically, these are either free games or games available for a "symbolic" fee. They are usually small in size and spread rapidly. Moreover, the relative simplicity of the project allows for quick modifications to game elements and rapid release to the market.

Such games are characterized by innovative ideas or revolutionary approaches to genres. One of the best examples of those products – Vampire Survivors. Created by one person it follows last trends: new updated, gamers involvement, immersive content.

Clearly, lacking sufficient resources to sustain a large development team and achieve popularity, the only practical way to explore the game development process is by creating one's own product while maintaining all the main stages of development. An indie game can serve as such a product.

Among the vast array of platforms available, the Arduino Uno, a versatile and widely adopted microcontroller board, has emerged as a promising candidate for creating specialized game computer systems. The Arduino Uno's flexibility, ease of programming, and cost-effectiveness make it an attractive choice for hobbyists and developers alike, opening up new possibilities for gaming innovation.

In this scientific article, we present a comprehensive exploration of the concept and implementation of a specialized game computer system based on the Arduino Uno platform. Our research delves into the fundamental components and functionalities that constitute such a system, addressing the challenges and opportunities that arise during its development.

The primary objective of this study is to investigate the capabilities and limitations of the Arduino Uno as a game computer system, with a focus on achieving optimal performance and providing an engaging user experience [9-11]. We aim to demonstrate the potential of this platform for creating unique and interactive gaming experiences that align with modern gaming expectations.

To achieve our research goals, we have undertaken an in-depth analysis of the Arduino Uno's hardware specifications, processing capabilities, and memory resources [12]. Furthermore, we have developed and tested a prototype game computer system that showcases the feasibility and potential of the platform.

In the subsequent sections of this article, we will discuss the related work in the domain of specialized game computer systems, explore the design considerations for implementing gaming functionalities on the Arduino Uno, and present the development process of our prototype system. Additionally, we will conduct performance evaluations, considering factors such as frame rates, latency, and power consumption.

This article aims to shed light on the capabilities and prospects of specialized game computer systems based on the Arduino Uno, highlighting their relevance in modern gaming scenarios.

Methodology. The best way to learn about indie game development is through creating your own project, preferably without using ready-made game engines, which would simplify the development process on one hand but impose certain limitations on the other. Source analysis has shown that simply creating a game is not enough for a successful indie project. In order to appeal to users, they need to be interested in the product. Therefore, in addition to developing the game itself, it is necessary to create specialized controllers that will enhance integration into the gameplay and also develop a web application that can attract a wide range of potential players.

Thus, a system created from scratch will encounter most of the processes and issues that arise during the development of similar products.

The main goal of developing the system is to create a complete product with accompanying documentation, and based on it, research the development processes.

Steps to a achieve: investigate game market, create tech requirements and test plan, create scheme, start development phase, test all system components isolated and integration, update test documentation, create .exe, support.

Results and discussion.

The system should meet the following requirements: 1) implementation of multiple interfaces with the ability to interact with each other. Mandatory interfaces include a web resource and a desktop application; 2) conducting testing (unit, manual, etc.) of the developed system as a whole, as well as its individual components; 3) scalability of the system; 4) utilization of design patterns; 5) providing access to view the development stages; 6) development of supporting documentation for the created computer system.

Fig. 1 shows a simplified diagram of the entire system. The desktop application will be the central component of the system, interacting with other elements such as the web application and the system controller.

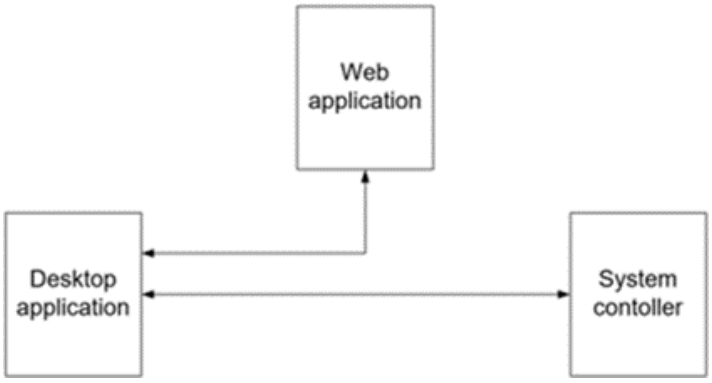


Fig. 1. Simplified scheme of the system

It is expected that the controller is not a mandatory component of the system.

If the port to which it should be connected does not send the corresponding signal, the user will control the game process using a standard keyboard. However, if the controller is connected, all in- game interactions with the keyboard will be ignored. Since the controller also

serves as a score counter, it is necessary to consider delays in data transmission and synchronization between the components.

The web application, on the other hand, will have no direct relation to the controller and will serve as an auxiliary service for hosting necessary information and storing game results. Reverse communication will be implemented through "pulling" the results table into the desktop application. The desktop application itself will process input signals, send output signals, and manage its processes.

For a better understanding of the processes and connection of all components of the game joystick, an electrical functional scheme was developed (Fig. 2). It consists of several interconnected components: Arduino Uno R3 - the computational component of the entire controller, an analog stick, a touch sensor button, LCD and TFT displays.

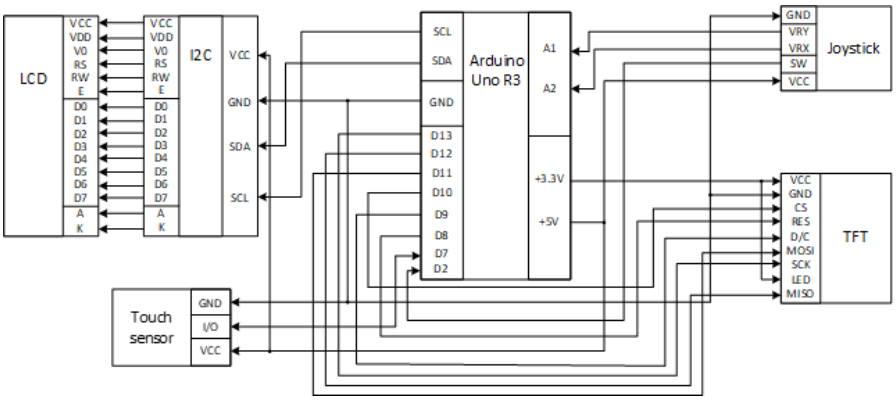


Fig. 2. The electrical functional diagram of controller

The scheme was created in several stages. Each stage involved the addition of an additional component. Thus, at the beginning, the analog stick was connected: it receives GND and VCC and transmits the current position of the stick. Next, the touch sensor was connected. With this set, testing of the controller could already be carried out.

An I2C adapter was used to connect the LCD display, which allowed saving a significant number of outputs on the board. In turn, the adapter is connected to the display itself with corresponding pins. The TFT display is a rather sensitive element, so it is powered by 3.3V, and other pins are connected to the respective digital pins, which need to be declared in the firmware code in the correct sequence.

As a result, only 2 elements have feedback with the computational center - the analog pin, which signals the button press and continuously transmits its current position through analog pins, and the touch sensor button.

The implementation of the controller itself took place in several stages, each of which involved the installation of an additional module and writing an additional code fragment enclosed in a function. Thus, to change the functionality of a specific module, you need to work with a specific function.

The most non-obvious was the implementation of signal transmission for movement: all possible positions of the stick (within a radius of 512 units) were divided into 9 sectors. Each sector corresponded to a certain direction (up, down, left, right, intermediate movements -

simultaneously up and left, idle state). Thus, in each iteration of reading, the desktop application received values indicating the necessary movement of the user's game object.

After reading the position of the stick, the main check takes place: if the position corresponds to the idle value, a decision is made to transmit a "null" value (indicating that the controller is in a state of rest) or to transmit a signal for movement in the corresponding direction. The entire physical controller can be seen in Fig. 3.

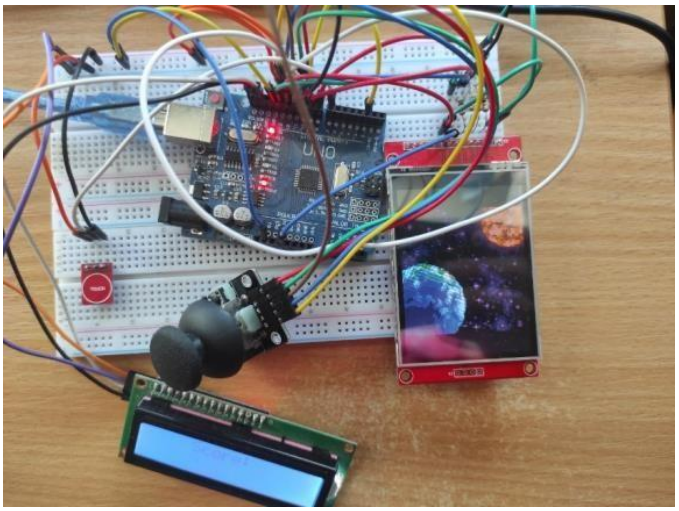


Fig. 3. The controller of designed system

One of the key decisions was to check the port with the controller. Therefore, the desktop application was designed to receive data from the keyboard if the controller was not connected, or from the controller itself. This way, the user does not have to worry about controller settings.

Desktop application is a game of interaction of objects with each other with a refresh of the screen, with a frequency set by the bitrate. In the center of the application is a ship with a certain amount of HP. The game continues until his health reaches 0. The player has the ability to control the ship in all sides of the 2D world, as well as perform a shot. Enemy objects with a predetermined trajectory can hit the ship, reducing its HP. There is a system of bonuses, counting points, saving the last ones. The graph diagram of the algorithm of the functioning of one object for one bitrate is presented in Fig. 4.

The implementation of the web application is specific, as a significant part of the development was dedicated to design decisions (the absence of a background). At the initial stage of development, a menu was created for navigation between website pages.

The website is responsive, meaning that the sizes of the menu and other elements adjust to any screen resolution, allowing users to access the website on computers with different screen sizes.

Additionally, the website features a leaderboard table that is updated according to the results from the desktop application. Part of the web application can be seen in Fig. 5. As you can see, text and menu options (icons and text on left side of screenshots) changed dynamically

due to monitor resolution. It makes app user-friendly and avoid issues which depends on user screen resolution.

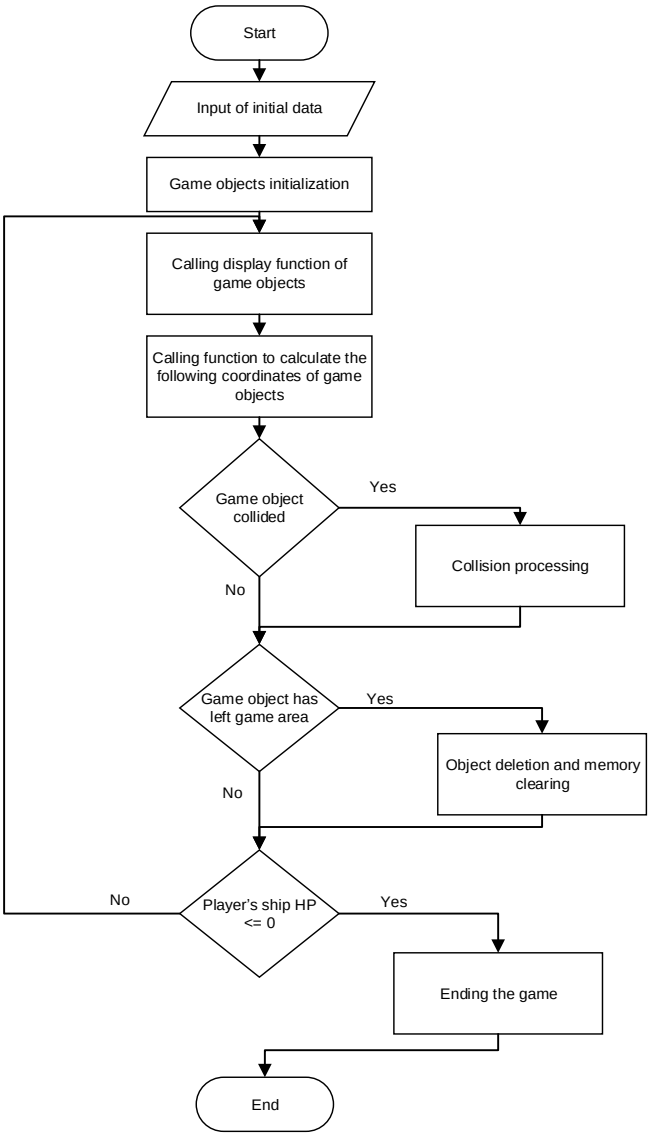


Fig. 4. Algorithm of functioning of one object for one bitrate

The desktop part is a rewrite of an existing screen with positions of various game objects that can interact with each other. In addition, all processes are tied to an internal refresh timer, which allows for data retrieval/transmission with the controller, avoiding various queues and delays.

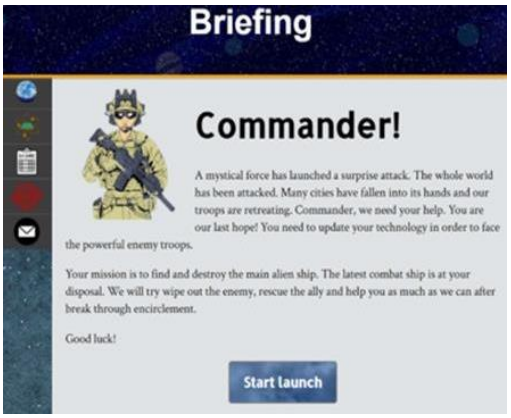


Fig. 5. The web part window of designed system

The desktop application, utilizing a range of design patterns, allows for quick addition of new objects and modification of existing ones, enabling the user to directly influence the gameplay through configuration files. Fig. 6 contains one of frames of the desktop application.

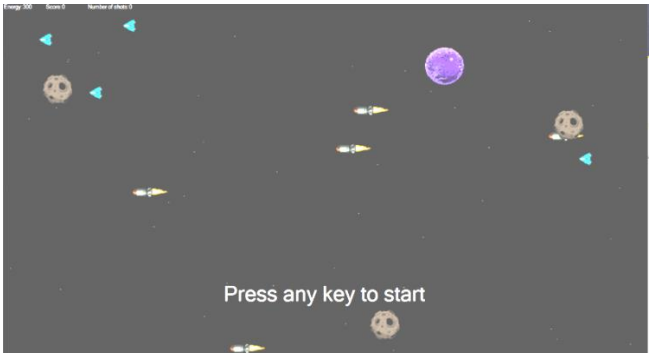


Fig. 6. The desktop part window of designed system

To include users in game process deeply, current concept support using custom game models. If user want to change any of item, all that it has to do – create his whole folder with appropriate images and change targeted path in config file. After this all item will use new models. Manual testing was conducted for all components individually, as well as integration/system testing.

For testing, we used our own documentation, as well as the TestRail platform. In addition, the built-in test system of Visual Studio allows you to describe auto-tests yourself and check them directly in the development environment.

Testing is divided into: manual (functional), automation. For testing the Web-application (Fig. 7), the IDE capabilities were used to make sure that the loaded page contains the expected data.

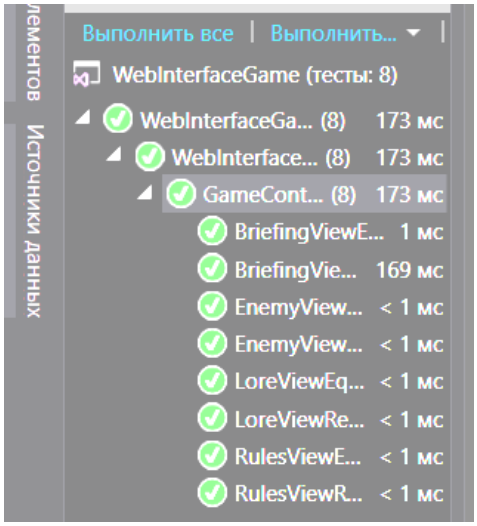
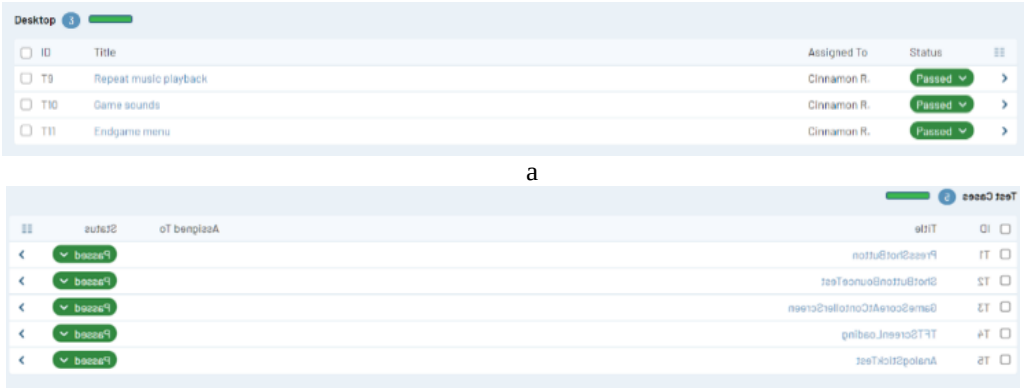


Fig. 7. Web-application testing

Desktop and hardware interfaces (Fig. 8) were tested in manual mode, since their interaction is quite easy to assess visually.



a

b

Fig. 8. Desktop application (a) and the game controller testing

The obtained research results can be used in further studies of the gaming industry. The developed project can be expanded, and the documentation created during the development process can be modified. For example, another software product can be developed using different concepts (such as using ready-made game engines, open-source applications, etc.), testing methods, technologies, and workforce, and the results can be compared to identify differences.

Regarding the further expansion of the product, it is possible to increase the number of gameplay mechanics, create sandbox environments, levels, and provide more freedom to the player (even involving them in the development process, allowing them to design their own levels, units, etc.). Add possibility to create new units with unique model view, parameters and trajectory, so it will become simple game sandbox.

Additionally, one can attempt to release the project on a gaming platform and continue researching the life cycle of the game product during the release and support stages.

Conclusion. The result of the work is the developed concept of an indie project according to the given task specification, as well as its further implementation in the form of interacting modules within a single system. The system consists of three interfaces that interact with each other and can be expanded in the future. The project possesses all the necessary characteristics of a computer system, which are dedicated to several sections.

Necessary supporting documentation has been created, providing a detailed description of the system's features, characteristics, and so on. The developed concept, as well as the possibility of comparing it with existing developments, allows for identifying its advantages, disadvantages, and potential directions for improvement.

The further implementation has helped to better assess all stages of game development, as they were brought closer to reality. Various implementation problems were identified at different stages, and strategies for overcoming them were developed. Project can be found by the link: https://github.com/c1nnamon-ro11/Game/tree/RefactorV3.

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СПЕЦІАЛІЗОВАНА ІГРОВА КОМП'ЮТЕРНА СИСТЕМА НА БАЗІ ARDUINO UNO

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У даній дослідницькій роботі була успішно спроєктована та реалізована спеціалізована ігрова система, яка використовує мікроконтролер Arduino Uno. Концепція проекту включала в себе високоякісну інтеграцію взаємодіючих модулів, що об'єднувалися в єдину систему. У центрі системи розташовані три інтерфейси, які не тільки взаємодіють, але й можуть легко розширюватися у майбутньому. Реалізація передбачала створення трьох окремих взаємодіючих частин: Desktop-додатку, Web-додатку та ігрового контролера. Робота була поділена на шість частин, включаючи реалізацію кожного з компонентів, їх інтеграцію, підбиття підсумків та висновки щодо розробленого інді-проєкту.

Ключові характеристики комп'ютерної системи були ретельно розділені на різні розділи, що сприяло більш ефективній розробці та впровадженню. Супровідна документація, яка включала детальний опис можливостей та характеристик системи, була створена для полегшення розуміння та взаємодії з проектом.

Концепція системи була ретельно розроблена, і порівняльний аналіз із сучасними розробками дозволив виявити переваги та недоліки, а також визначити потенційні напрями для подальшого вдосконалення. Результатом був розроблений продукт, який не тільки враховує поточні стандарти галузі, але й виходить за їх межі, пропонуючи інноваційні рішення.

Важливим етапом впровадження системи було оцінювання всіх етапів розробки гри в умовах, які були якнайбільше наближені до реальності. Це дозволило виявити потенційні труднощі та вдосконалити систему, забезпечуючи її оптимальне функціонування в реальних умовах.

Узагальнюючи, проєкт успішно втілив ідею ігрової системи, яка відповідає сучасним вимогам та відкриває перспективи для майбутнього розвитку та розширення. Його концепція та реалізація представляють собою цінний внесок у сферу інді-розробок, демонструючи високий рівень технічної та концептуальної майстерності.

Ключові слова: інді-розробка, ААА-проект, ігровий контролер, концепт гри.

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