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Three Dimensional(3D) Education Game Development for Treatment Assistance with High-Functioning Autism

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Abstract

Due to rapid socio-economic development and environmental changes, particularly autism spectrum disorder (ASD) in the context of Attention Deficit Hyperactivity Disorder (ADHD) and high-functioning autism, has become a significant social issue. This issue is increasingly recognized from a societal perspective rather than just an individual or family problem. But there remains a lack of information in frontline education. Traditionally, treatment for ASD has been conducted in specialized institutions, or by professional doctors, therapists, and counselors. There are still several challenges such as 1) accessibility to hospitals and transportation for children with ASD, 2) the maturity and competence of therapists, and 3) the lack of appropriate educational content. To solve these problems, we propose a supplementary 3D educational game process for children with high-functioning autism that utilize speech recognition technology and games designed for continuous and repetitive learning. Our proposed game content can be used at home, which incorporates Speech-To-Text (STT) technology and mini-games to help children indirectly experience and learn to handle unexpected real-life situations. With this approach, we will expect that the children can develop social skills and enhance the efficiency of their treatment.

Keywords: *Game, Voice Recognition, Speech To Text (STT), High Functioning Autism*

1. INTRODUCTION

There is an increasing interest in and demand for special education recently. Particularly, awareness of autism spectrum disorder(ASD) is growing through various media, including recent dramas and children's programs such as "Extraordinary Attorney Woo" and "Dingdongdeng Kindergarten," which have introduced various creative works related to autism to the public. However, educational resources and approaches regarding autism remain insufficient [1]. In particular, there is a lack of awareness among teachers and special education professionals, and there are not enough institutions to provide special education. This paper focuses on a project to create an educational website called Growing Interaction Odyssey (GIO), targeting children aged 8 to 10 with high-functioning autism within the ASD. It specifically explores how these educational challenges can be addressed from a technical perspective and aims to propose a method to improve the

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interaction skills and sociality of children with autism through a web-based platform. Through this, we seek to explore technological approaches and solutions in the field of special education, providing detailed technical specifications and implementation methods. Chapter 2 discusses related research and case studies. Chapter 3 mentions therapy-assisted 3D education. The final chapter mentions the conclusion.

2. RELATED WORK

Among recent issues, Asperger's Syndrome, a type of high-functioning autism, is a developmental disorder characterized by difficulties in social interaction and nonverbal communication. This syndrome is marked by restricted and repetitive interests and activities and is included within the ASD. However, it does not directly affect intelligence or language development [2].

The STT technology converts human speech into text format. This technology utilizes speech recognition to collect voice data and transform it into textual data. It is used in various fields such as voice commands, automatic transcription, and customer support automation, increasing accessibility and efficiency by converting users' speech into real-time text [3].

There have been many attempts at IT-based special education for children with high-functioning autism. However, there is a lack of research on assessing children's linguistic abilities, particularly in evaluating their syntactic skills and storytelling in discourse situations where they must maintain and express a single topic [3].

Additionally, studies have distinguished the syntactic and storytelling abilities of children with high-functioning autism by comparing them to typically developing children through storytelling using robots and PCs. The findings indicate that children with high-functioning autism use less complex syntax than their typically developing peers, and no statistically significant differences were observed between the PC and robot mediums [2].

The game "Look at Me" is an application designed to develop social communication skills, which are fundamental to forming social relationships. "Look at Me" is an app that "trains" users on how to communicate with others [5]. While this game focuses solely on non-verbal training, we aim to add verbal training as well. Another game, "Lulu and Chichi's Earth Adaptation," is a program that helps children with developmental disabilities learn functional skills necessary for daily life, enabling them to handle various situations. However, it lacks social skills training for interactions with others in everyday situations. Therefore, our goal is to facilitate the growth of these children through learning, helping them better adapt to society [6]. Currently, various approaches are being explored. This paper proposes a therapy-assisted 3D educational game to improve temporal accessibility.

3. Game process for interaction with high-functioning autistic children

3.1 Scenario-based testing with speech recognition functionality

Figure 1 is the entire game progress process of the game for social adaptation training for children with disabilities. It is a complete flow chart of how to interact with NPCs and how to proceed with the game for social adaptation training from the homepage access. When all the games for each situation are completed, you can check the improvement in the social adaptation training stage with scores and graphs.

- **Step 0 : Provide environment**

Earlier, the main stages of the game are set in five different areas that high-functioning autistic children, the target group, would easily encounter in the real world: four common locations (school, library, park, supermarket) and one location for communication with elders (community center). To implement this on the web, the 3D library Three.js is used.

- **Step 1 : Identify needs**

High-functioning autism does not involve intellectual disability, but individuals with this condition often

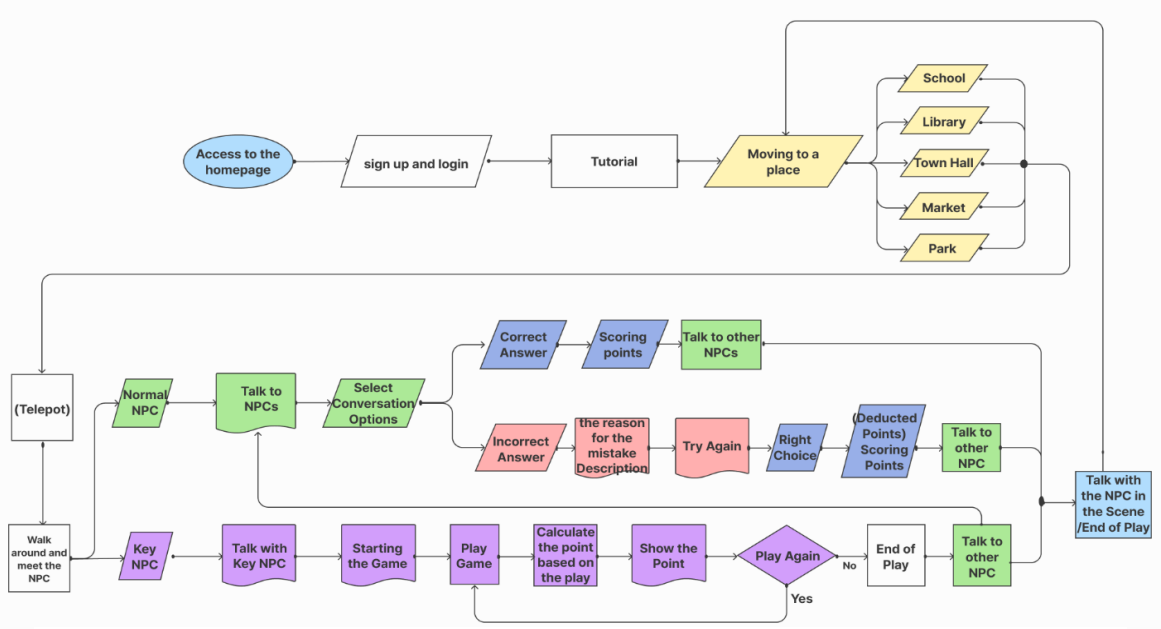

Figure 1. Overall game progression process

struggle significantly with understanding what others are feeling and thinking. They find it difficult to grasp that others may have thoughts and feelings different from their own. Emotional regulation can also be challenging, leading to inappropriate behaviors such as crying, tantrums, or, at times, aggressive or violent actions. Additionally, they tend to selectively focus only on areas of interest and lack joint attention skills, which are necessary for sharing focus with others. They may speak in single words, repeat the same phrases, or use various forms of echolalia. They also have difficulty reading others' facial expressions or nuances and may not use facial expressions, gestures, or body language appropriately. Their speech may lack emotional tone, and they may speak in a mechanical manner.

To address the symptoms mentioned, a program is created that presents everyday situations to help children develop pragmatic language skills through conversations with NPCs. The goal is for children to understand and express both others' emotions and their own through the game.

Figure 2 shows five typical symptoms of autistic children. Autistic children have difficulty with social interaction. They do not understand what others are thinking or feeling. They have difficulty controlling their emotions and express them through inappropriate behavior. They focus only on areas of interest and are unable to share their attention with others. They also speak only one word or repeat the same phrase over and over. They do not appropriately use the facial expressions or movements of others. They also have characteristics such as not being able to express emotions in their voices and speaking mechanically [7].

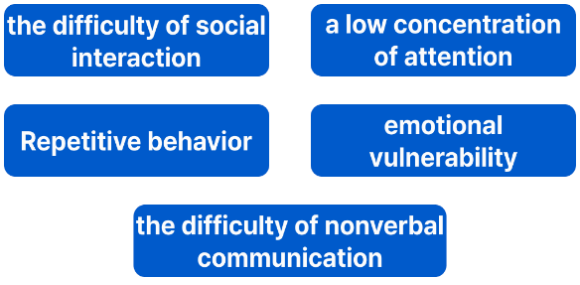

Figure 2. Representative symptoms of autistic children

Figure 3 shows the speech recognition process within the game process. When the trainer says a sentence that he or she thinks is correct, the speech recognition data is transmitted and converted into text to determine whether the corresponding choice is correct. If correct, the score is saved and the conversation ends.

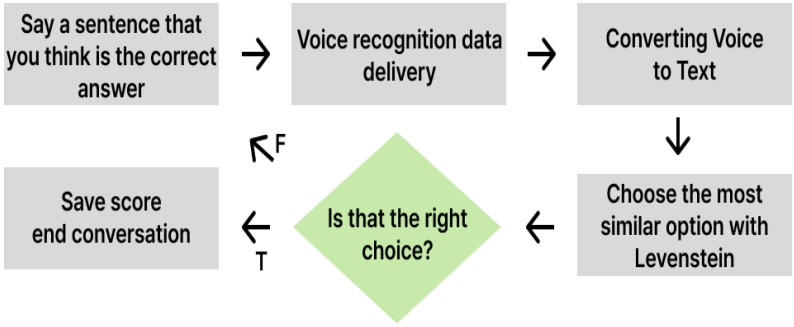

Figure 3. Voice recognition process

■ **Step 2 : Application of speech recognition technology for communication solutions**

To address the listed issues, an interactive system is implemented using speech recognition technologies. Text-To-Speech(TTS) is used to convert the program's text output into spoken words for the user, while STT is used to convert the user's spoken responses into text and send it to the server. This system creates a conversational environment where users can speak and hear responses, even in a virtual setting[8]. In STT process of the above procedure, due to the potential inaccuracies in speech recognition, our program presents multiple-choice options for responses[9]. The program uses the Levenshtein algorithm to compare the text of the presented choices with the text converted from the user's spoken response. This comparison helps determine which choice the user has selected[2].

■ **Step 3 : Create virtual conversational agents**

The virtual conversational agents in the environment are referred to as NPCs (Non-Player Characters). A total of 20 conversational agents were created, with 5 NPCs assigned to each location[10].

- School: Teacher, Passing student, Principal, Injured friend

- Library: Student who drop something, Person reading a book, Child retrieving a book, Person using the reading desk

- Community Center: Grandfather, Women's Association Chairperson, Grandmother, Grandmother's granddaughter

- Park: Person who drops something, Sign for feeding ducks (100 won), Man walking his dog, Fountain

- Supermarket: Woman shopping, Seafood special promotion staff, Sampling station staff, Supermarket cashier

Figure 4. Placed NPCs (passing friends, grandfathers)

Figure 4 shows NPCs in the interactive game. These NPCs are composed of "passing friends" and "neighborhood grandpas" that the trainer can feel friendly with.

Step 4 : Scenario definition

Each NPC placed in various locations is assigned realistic dialogue scenarios to help players act appropriately based on learned knowledge when encountering similar situations in real life.

a. School:

- Conversation with a teacher who greets the player for the first time
- Interaction with a friend who bumps into the player while passing through the playground
- Greeting the principal
- Conversation with an injured friend who has fallen

b. Library:

- Helping a student who drops their glasses and pencil case by picking up their items
- Assisting a child who cannot reach a book due to their height
- Asking a child reading an interesting comic book if they can see the book
- Dealing with a situation where someone is already using the reading desk that you want to use

Figure 5 shows the NPC process within the interactive game. You can see how the NPCs interact with the trainer in each situation.

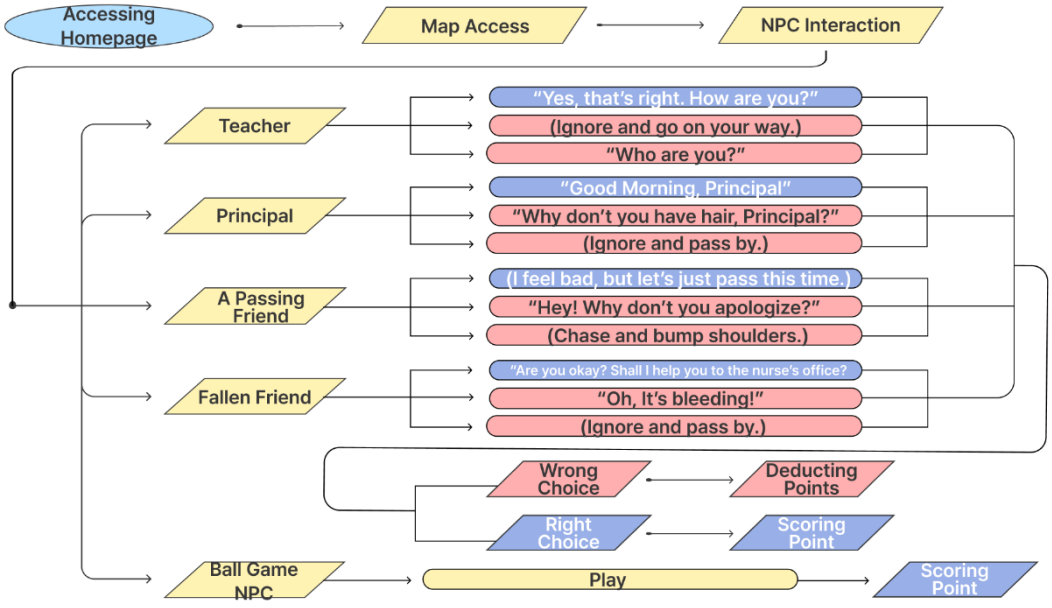

Figure 5. The entire flow of the game training process

c. Community Center:

- Conversation with a grandfather who has poor hearing
- Reacting to someone splashing water on you while they are watering plants
- Interaction with a grandmother who is curious about the location of the grandfather
- Conversation with the granddaughter of a grandmother who is struggling to fold paper neatly while

doing origami

d. Park:

- Helping someone who drops their wallet from their bag
- Understanding the meaning of the sign indicating 100 won for feeding ducks at the lakeside
- Asking a man walking his dog if it is okay to greet the dog
- Noting the sign at the fountain that says not to throw coins in

e. Supermarket:

- Greeting and conversing with a woman shopping
- Talking to a staff member promoting seafood discounts
- Engaging with a sampling station employee offering food samples
- Conversing with a supermarket cashier

Figure 6 shows the process of playing a ball game with an NPC. After talking to an NPC and playing a game, the score is saved in the DB and the score trend can be checked on the trainer's My Page.

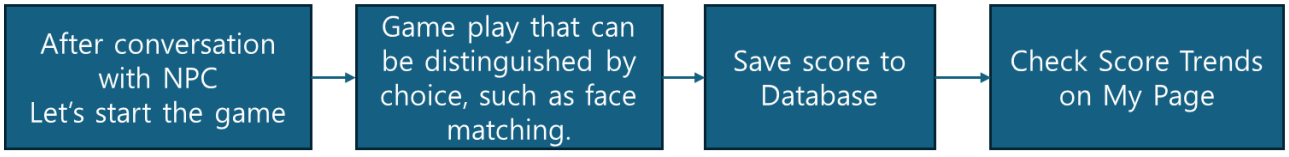

Figure 6. Ball game process

■ **Step 5 : Game mechanics**

To address the symptoms identified in Step 1, an additional mini-game is created for each location, with each mini-game focusing on a specific improvement element. This was implemented using Unity.

■ **Step 6: Educational training with autistic children and NPC**

Through interactions between autistic children and NPCs, various scenarios are presented. The child must choose the correct option for each situation. When the correct option is selected, a score is recorded, and if the wrong option is chosen, the child is given another chance to try.

■ **Step 7: Measuring educational training performance**

Measuring educational training performance is a crucial step. Without face-to-face assessment or direct evaluation by experts, it is difficult to determine how much the child's abilities have improved**.**

It is essential to have standardized metrics to demonstrate that both guardians and children have seen improvements in their abilities. In this process, conversations with each NPC and game scores are recorded using a database. Activity scores are logged, and can be reviewed in a data table, such as a line graph, showing the scores for each date. This allows for the observation of progress in the child's social skills, pragmatic language, and emotional expression, indicating their increased maturity and better preparedness for social situations. Figure 7 shows the individual data page for each situation. You can check the trainer's score according to the situation.

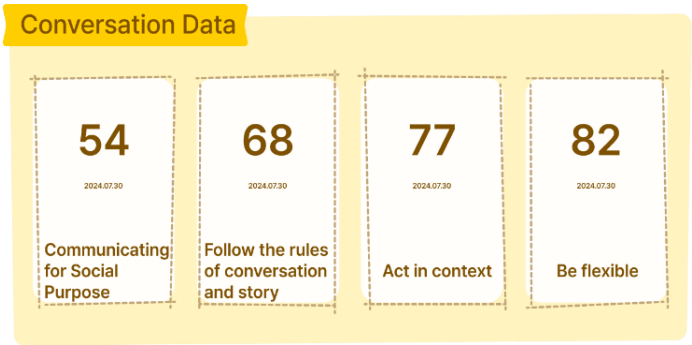

Figure 7. Personal data pages for each situation

Figure 8 is a graph of interactions with NPCs. The graph shows how much interaction occurred with each NPC in a given situation.

Figure 8. Interaction graph with NPCs

■ **Step 8: Implementation based on the above steps education**

The Unity game is built with WebGL and loaded in an iframe format. A data-path is assigned to each object so that when an object is clicked, the game path corresponding to that object is changed, ensuring that the correct game is loaded for each object.

Figure 9 shows the implementation of ball play with NPCs in Unity, and the code for bringing the implemented Unity game to the web.

```
// WebGL용 서브 애플리케이션과 서버 설정
const webglApp = express();

function setCustomHeaders(req, res, next) {
  const ext = path.extname(req.path);

  switch (ext) {
    case '.wasm':
      res.setHeader('Content-Type', 'application/wasm');
      break;
    case '.gz':
      res.setHeader('Content-Encoding', 'gzip');
      if (req.path.endsWith('.data.gz')) {
        res.setHeader('Content-Type', 'application/octet-stream');
      } else if (req.path.endsWith('.js.gz')) {
        res.setHeader('Content-Type', 'application/javascript');
      } else if (req.path.endsWith('.wasm.gz')) {
        res.setHeader('Content-Type', 'application/wasm');
      } else {
        res.setHeader('Content-Type', 'application/gzip');
      }
      break;
    default:
      break;
  }
  next();
}

// 미들웨어를 정적 파일 서빙 전에 적용
webglApp.use(cors());
webglApp.use(setCustomHeaders);
webglApp.use(express.static('MiniGames'));

const WEBGL_PORT = 8080;
const webglServer = http.createServer(webglApp);
webglServer.listen(WEBGL_PORT, () => {
```

Figure 9. Implementing a server to load a unity game

4. CONCLUSION

We propose a web-based functional game designed to facilitate the smooth integration of high-functioning autistic children into school social life through practice. High-functioning autistic children often lack the pragmatic language skills necessary for natural conversations with others. To address this, the game presents various everyday scenarios and structures dialogue options with NPCs to help children develop their pragmatic language abilities. By navigating these simulated interactions, children can learn how to interpret social cues, understand conversational context, and select appropriate responses. The goal is to help children better integrate into real-world social situations and improve their judgment and response to unexpected situations. Furthermore, the game will adapt to each child's progress, gradually increasing the complexity of scenarios to challenge and enhance their communication skills. We expect that children can improve their ability to communicate effectively for social purposes. The game also provides feedback and tips to guide them through the learning process, ensuring a supportive environment for growth. Ultimately, this approach aims to build confidence in children, enabling them to engage more meaningfully with their peers and educators in everyday settings.

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