CPT208— PORTFOLIO

Xi'an Jiaotong-Liverpool University 西交利物浦大学

AUTISM RECOVER

——Building Bridges Through AR

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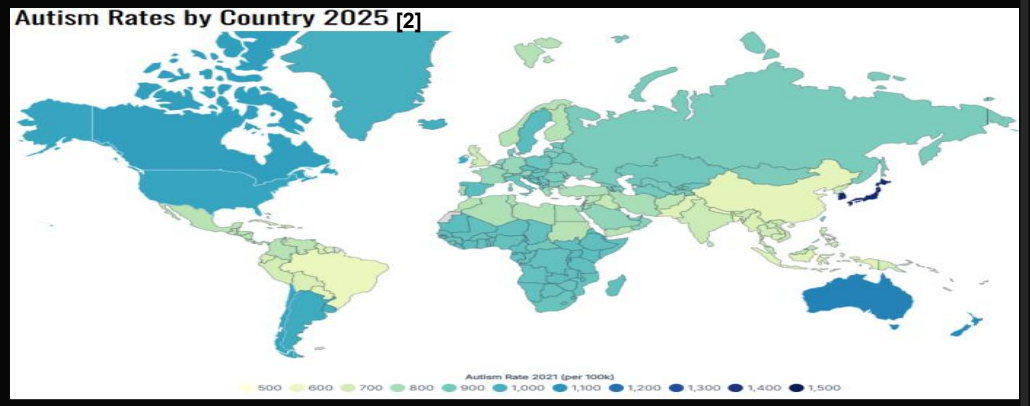
INTRODUCTION & PROBLEM STATEMENT

Topic and Domain

- Generative AI in Autism Recover: Using AI to create personalized solutions for children with autism, addressing challenges in social interaction and sensory processing.
- Approach: Combining Generative AI with Augmented Reality (AR) to transform children's drawings into interactive 3D scenes, fostering creativity and social development.

Existing Work & Project Differentiation

Existing Research: Studies (e.g., Sahin et al.[1]) have explored AR for autism rehabilitation, showing positive effects on social communication.Difference: This project combines GAI with AR, creating a more dynamic, personalized experience by turning drawings into 3D characters, filling gaps in existing methods.



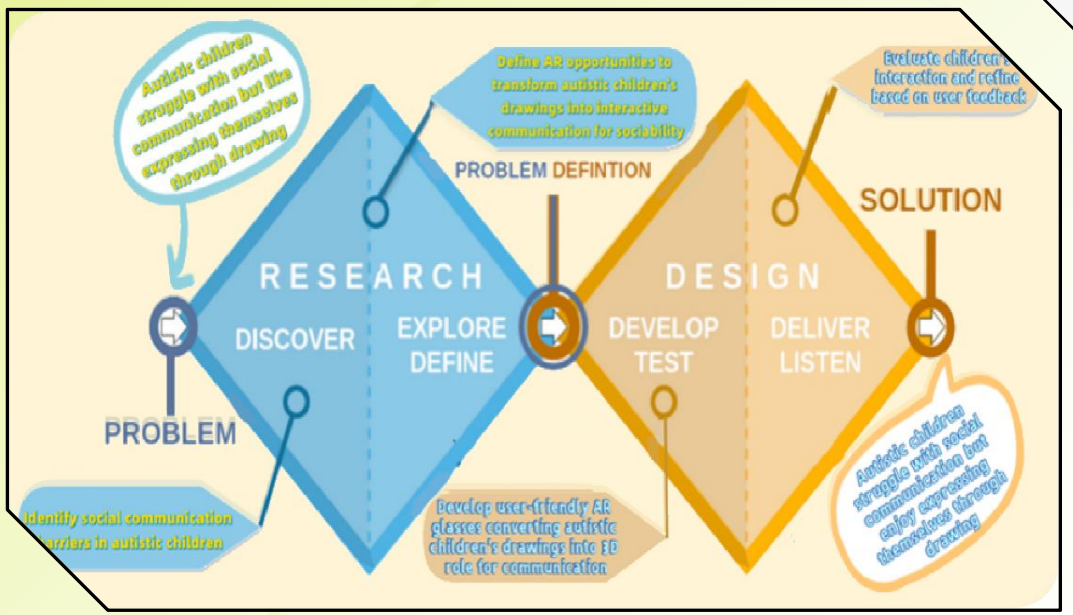
Problem or Opportunity

- Problem: Children with autism often face significant social interaction barriers, leading to challenges in communication and emotional expression. Many of these children enjoy drawing but struggle to convey their emotions and engage socially.
- Opportunity: By leveraging GAI and AR, this project provides an immersive and adaptive experience for children, turning their drawings into interactive 3D characters that foster communication and social skills development.

Human-Centric Computing Relevance: Focuses on improving the lives of children with autism through personalized, empathetic technology that supports emotional and social growth.

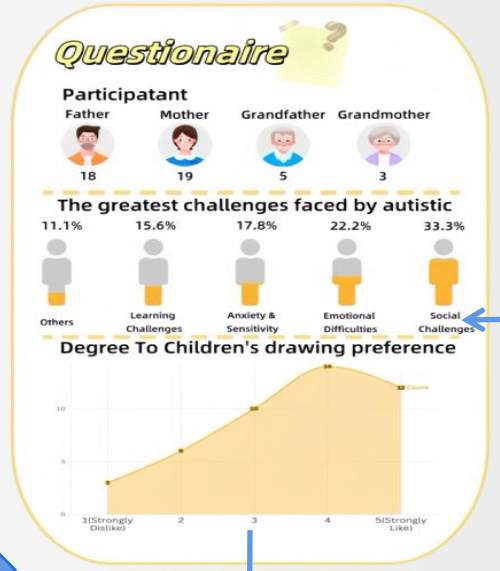
ITERATION1 —— PRELIMINARY DESIGN & EXPLORATION STAGE

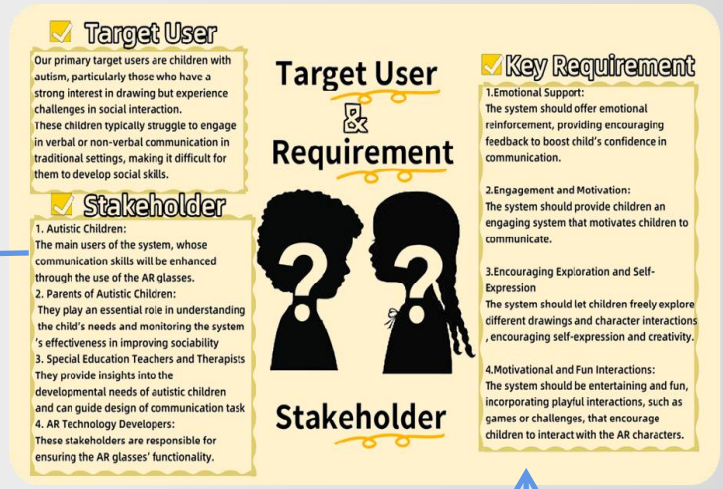
Firstly, We have decided:

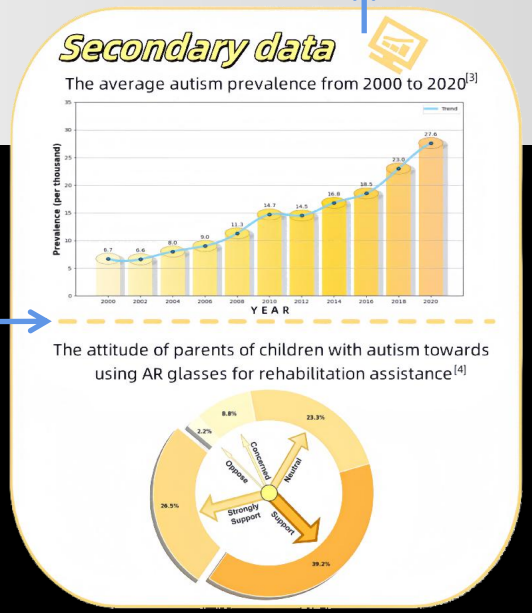


- Entire project adopt the iterative design approach.
- From the stage of identifying problems to the evaluation stage, we have employed the double diamond model.

Discovering Requirements

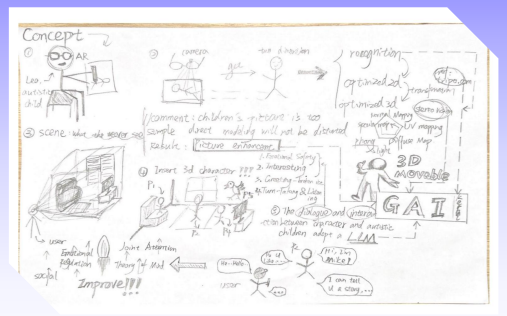


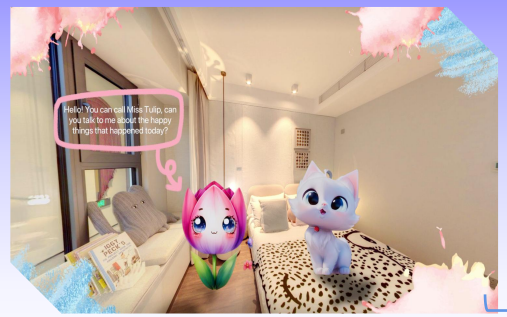




ITERATION1 —— PRELIMINARY DESIGN & EXPLORATION STAGE

Design Result - drawn pictures are transformed into 3D characters.





Sketch → Low Fidelity

Evaluation

Dr. Shi

- Heuristic Evaluation
- Benchmark: Nielsen's 10 Usability Heuristics
- Summary: Dr. Shi identified five key usability issues and praised the prototype's minimalist focus. Priority should be given to improving process visibility and operation guidance.

Seven parents

- Usability Testing
- Satisfaction (1–5): 3.8
- Verbal Feedback: "The flow is simple", "Children are sometimes not interested in this effect", "The entire scene elements are too complex, which may make children feel uncomfortable and at a loss"...

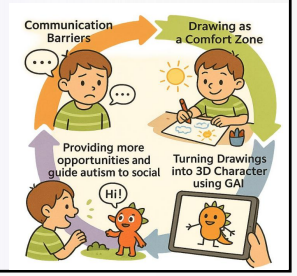
To sum up: The sketches and low-fidelity models of Iteration 1 received high recognition during the proof-of-concept stage, but there were deficiencies in terms of picture comfort and operation guidance. The subsequent iterations will focus on optimizing these two points to ensure that both children with autism and their parents can smoothly and independently complete the entire experience process.

ITERATION2 —— CONTINUOUSLY REFLECT & OPTIMIZE MODEL

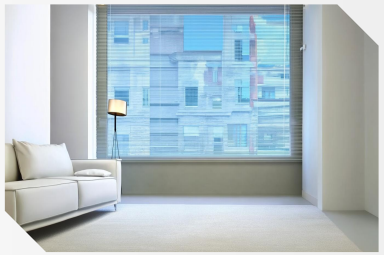
Reflection and Discovery

-from iteration1

- Autistic children are at the center. How can we make them feel comfortable?
- Autistic children need guidance. We should not leave them feeling at a loss.
- For augmented reality, the visuals must be more compelling and be able to blend well with the surrounding environment.



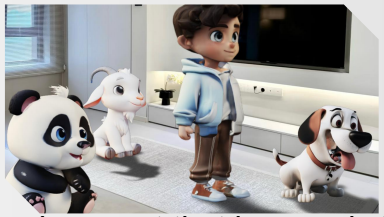
How to design?



Unity + GAI

UI Design: Figma

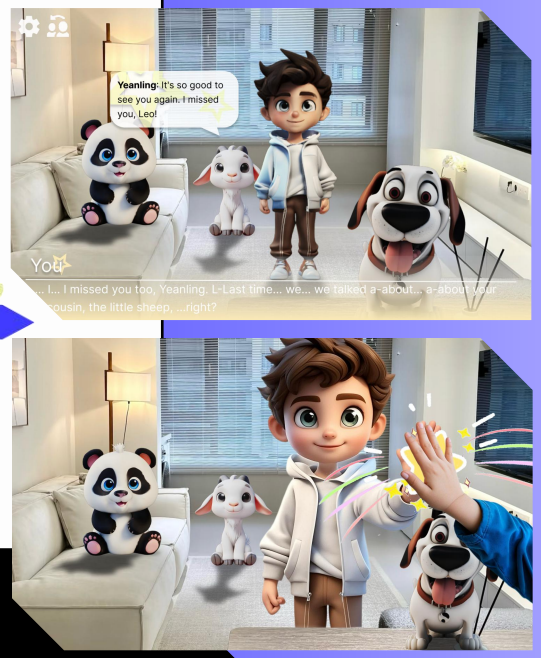
3D Technical Support



- Carry out the simulation in an environment that is more in line with the daily family life.
- Careful consideration of interactive actions can guide autistic children in their interactions, enhancing their psychological comfort and social skills.

ITERATION2 —— CONTINUOUSLY REFLECT & OPTIMIZE MODEL

High Fidelity Result & Evaluation Process

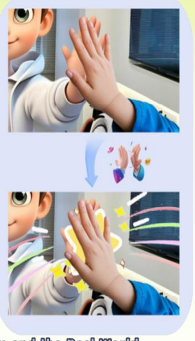


1

Heuristic Evaluation & Shneiderman Rules

- Consistency and Standards
- Offer informative feedback

Consistent Color System



Follow platform standard

- Match Between System and the Real World

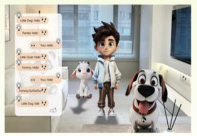
2

Evaluation-Usability Testing

Thinking about the versions	Interaction first VS content first

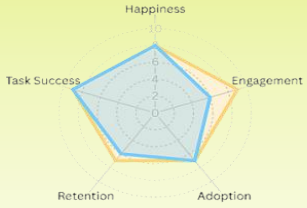
Preferences of child's parents

- ⅓ of the parents: B → A
- ⅔ of the parents: A → B



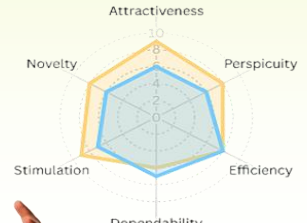
	Prototype A	Prototype B
	UEQ	UEQ
	HEART	HEART
	Text first / Friend first	Friend first / Text first

3



HEART Framework [5]

Alternative A Alternative B



UEQ Standard [6]

In Iteration 2, we conducted heuristic evaluations based on Schneiderman's rules, ensuring consistency, standardization, and alignment with real-world interactions. Usability testing compared two prototypes: one focusing on interaction first and the other on content first. Results from the UEQ and HEART framework revealed that Prototype A (interaction first) was preferred by most parents, showing higher engagement and satisfaction, with children more actively participating. The HEART framework also demonstrated positive outcomes across happiness, task success, and retention, further confirming the effectiveness of prioritizing interaction for improved communication.

ITERATION3 —— EMOTIONAL ANALYSIS & REAL-WORLD CONNECTION (PERSONAL IMPROVEMENT)

REFLECTION & RE-EXPLORATION

We got in touch with several families of autistic children through activities for autistic children in Suzhou Center:

- ***The design of the high-fidelity prototype fully took into account user feedback, successfully enhancing the interactivity and visual appeal of the interface.***
- ***Prototyping design is more in line with user needs, enabling children with autism to understand and use the product more intuitively.***

BUT!

- ***How can we truly understand the current state of mind of children with autism and what they really want? If there is only one guiding approach, will it make the children feel bored or lose their sense of novelty?***
- ***How to prevent children from getting addicted to the AR world and at the same time enhance their connection with reality? This is a huge and worthy core issue to be examined.***

ITERATION3 —— EMOTIONAL ANALYSIS & REAL-WORLD CONNECTION (PERSONAL IMPROVEMENT)

Design & Methodology

Emotion analysis technology + GAI

Give a hug.

OR

Let's sing!

OR

Play with us!

AR glasses can analyze the real-time moods of autistic children through emotion analysis technology, such as facial expression recognition and voice tone detection, to accurately assess their emotional state. Using this information, Generative AI (GAI) can trigger 3D characters to perform different guiding actions, such as calming gestures or encouraging prompts, to assist children in managing their emotions and interacting with their environment. This personalized response helps create a supportive, dynamic interaction that adjusts to the child's emotional needs in real time.

GAI's powerful generation technology

Start

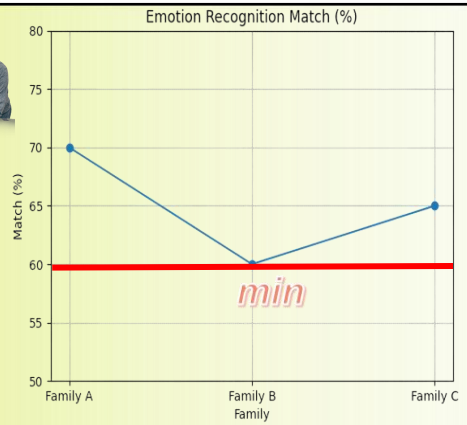
Where have they gone?

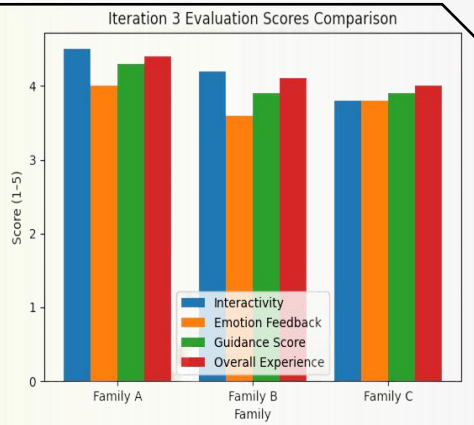
Go and seek help!

The guardian of the child can choose this function. GAI will generate scene-based short stories that match the surrounding environment accordingly, thereby guiding the child to enhance communication with parents or companions, and strengthening the connection between autistic children and the real world.

ITERATION3 —— EMOTIONAL ANALYSIS & REAL-WORLD CONNECTION (PERSONAL IMPROVEMENT)

Three families





- ✓ Parents can view their children's emotional feedback in real time on the terminal.
- ✓ All families reported that their children requested to use the system again the next day.
- ✓ Average Score: 4.15 / 5
- ✓ “The comforting voice and gestures were very gentle, which made me feel very reassured.”

Dr. Shi

Heuristic Evaluation, Task-Based Evaluation:

- ➢ ~66% consistency in emotion detection, especially accurate for “happy/sad” states
- ➢ “The emotional recognition strategy is still evolving, but it offers a non-intrusive method of emotional intervention.”
- ➢ "In the future version, I suggest optimizing the control panel on the parental side so that parents can provide real-time guidance on the interaction behaviors of the characters."

Evaluation & Discussion

Comprehensive discussion:

In the third iteration, the system accurately recognized emotions and adapted interactions to create a more comfortable experience; it successfully guided children to communicate with their parents, received positive feedback, and reinforced parent–child interaction and social willingness through gentle prompts. However, there are areas for improvement. Although emotion recognition performed well overall, it occasionally misclassified reflective states as “sad.” The set of interactive gestures remains limited, and some children were unresponsive to the few available actions; offering a wider variety of gestures could enhance engagement. Finally, parental intervention features are insufficient: while the system enables role-based interaction, parents lack real-time tools to step in when children refuse to engage or have difficulty expressing themselves, limiting effective involvement.

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CONCLUSION & FUTURE WORK

Summary of Outcomes:

The project, Autism Recover, successfully utilized Generative AI (GAI) combined with Augmented Reality (AR) to create a unique and personalized solution aimed at improving communication and social interaction for children with autism. Through the integration of AI and AR, children's drawings were transformed into interactive 3D characters, promoting creativity and fostering emotional and social development.

Throughout the iterations, the system demonstrated significant progress:

I. Iteration 1 established the foundational design based on user needs and insights from initial testing.

II. Iteration 2 refined the user interface and interaction flow, improving usability and introducing high-fidelity prototypes that resonated well with both children and parents.

III. Iteration 3 introduced emotion recognition capabilities, enabling the virtual character to adjust its behavior based on the child's emotional state. This iteration successfully guided children in engaging with their parents, improving social interactions and communication. Parent satisfaction was notably high, with an average score of 4.15/5.

Limitations:

Despite its success, the system still faces some limitations:

- Emotion Detection: While the system was able to detect basic emotions like happiness and sadness, its performance could be improved in recognizing more complex or subtle emotions.
- Gestures and Interaction: The range of interactive gestures remained limited, which resulted in lower engagement from some children.
- Parental Control: There was a lack of real-time tools for parents to adjust the interaction, especially when children were unwilling to engage or had difficulties with communication.

Acknowledgement and References:
[1] N. T. Sahin, N. U. Keshav, J. P. Salisbury, and A. Vahabzadeh, "Second version of Google Glass as a wearable socio-affective aid: positive school desirability, high usability, and theoretical framework in a sample of children with autism," *JMIR Human Factors*, vol. 5, no. 1, p. e8785, 2018.
[2] World Population Review, "Autism rates by country," World Population Review. [Online]. Available: https://worldpopulationreview.com/country-rankings/autism-rates-by-country. [Accessed: May 5, 2025].
[3]Centers for Disease Control and Prevention, "Autism spectrum disorder (ASD): Data & research," Centers for Disease Control and Prevention, [Online]. Available: https://www.cdc.gov/autism/data-research/index.html. [Accessed: Mar. 30, 2025].
[4] N. T. Sahin, N. U. Keshav, J. P. Salisbury, and A. Vahabzadeh, "Safety and lack of negative effects of wearable augmented-reality social communication aid for children and adults with autism," Journal of Clinical Medicine, vol. 7, no. 8, p. 188, 2018.
[5]B. Laugwitz, T. Held, and M. Schrepp, "Construction and evaluation of a user experience questionnaire," in Symposium of the Austrian HCI and Usability Engineering Group, Berlin, Heidelberg: Springer, 2008, pp. 63-76.
[6]K. Rodden, H. Hutchinson, and X. Fu, "Measuring the user experience on a large scale: user-centered metrics for web applications," in Proc. SIGCHI Conf. Human Factors in Computing Systems, 2010, pp. 2395-2398.

I would like to express my heartfelt thanks to Dr. Shi, the participating families, our supervisors Dr.Yue Li and Dr.Teng MA and all TAs, and my team members for their invaluable support and contributions to the success of this project.

Future Work:

To address these limitations and expand the system's capabilities, the following improvements and extensions are recommended:

- Enhance Emotion Recognition: Incorporating more sophisticated machine learning models for emotion recognition, including multi-modal input (such as voice tone and facial expressions), will improve accuracy and ensure better handling of nuanced emotional states.
- Expand Interaction Range: A broader variety of interactive gestures (e.g., hugs, high-fives, and dancing) could increase children's engagement and provide a more immersive experience.
- Parental Interaction Tools: Developing a parent-side control panel that allows real-time adjustment of character behavior will increase parental involvement, enabling more dynamic guidance and support in the interaction process.
- Wider Application: Expanding the system's use to other environments, such as schools or therapy centers, could help more children with autism benefit from the system. This would also allow for group interactions and further support the social development of children in various settings.
- Cultural Adaptation: The system should be adapted to cater to different cultural contexts by integrating region-specific interaction styles, characters, and feedback mechanisms to make it more universally applicable.