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**Decision Support Systems - 99207 - Project Proposal**

# IRIS: AI-Powered Decision Support System for Therapists of Autistic Children

## Abstract

Recent advancements in Artificial Intelligence (AI) and Natural Language Processing (NLP) have enabled applications that were not feasible just a few years ago. Large Language Models (LLMs) can now understand human psychological states and social interactions, identify adversarial environments, and be taught, personalized, and customized.

IRIS, an application that leverages AI and NLP within a decision support system (DSS) helps verbal autistic children navigate social interactions. IRIS provides therapists for autistic children (mainly speech therapists and psychologists) with a toolkit powered by real-life events. Autistic children often misinterpret social situations, and therapists miss valuable information when relying solely on the child’s version of events.

IRIS acts as a reliable witness and documentarian. Triggered by a schedule, specific words, or recognized emotions from conversation analysis, it documents these events and provides therapists with summaries and AI-generated visual stories, facilitating personalized support.

During the training period, IRIS serves as a passive decision support system. Therapists provide feedback on summaries, visual stories, and alternative solutions suggested by IRIS to refine the model. Our vision is for IRIS to evolve into an active, real-time support system for autistic children, acting as a reliable agent on behalf of the therapist.

## Introduction

Many autistic children find social interactions challenging and confusing. They often require extra support and explicit guidance on the appropriate social conduct. Traditional methods involve a trained personal aide who accompanies the child throughout the day, an option that is labor-intensive and often costly. When no such aide is available, the lack of real-life insights may hamper the therapist’s ability to efficiently help the child.

Several projects have demonstrated the potential of technology in autism therapy. The Autism Glass Project at Stanford University, for instance, uses Google Glass to help autistic children recognize and interpret facial expressions by providing real-time emotional cues. This project, while promising, primarily focuses on facial expression recognition and does not address broader conversational contexts or visual story generation.

Other notable projects include robot-assisted therapy with robots like KASPAR and NAO, which model social behaviors and assist in therapy by engaging autistic children through interactive play. Virtual Reality (VR) interventions, such as those provided by platforms like Floreo, vTime XR, Social VR, and The Blue Room, simulate social situations in safe, controlled environments, allowing children to practice social skills with avatars. These platforms address scenarios ranging from basic interactions to complex social settings like job interviews. Samsung’s “Look at Me” app also aids in improving eye contact and understanding facial expressions through interactive games.

Significant interdisciplinary research has highlighted AI's potential in autism support. Scassellati, Admoni, and Matarić (2012) explored the use of robots in autism research, emphasizing the transformative impact of interactive technologies [[1](#72oeqokk0961)]. Goodwin (2008) discussed the promise of innovative technology in accelerating autism research and treatment [[2](#4m1jc63zkjdv)]. Gotham et al. (2007) and Bone et al. (2016) enhanced decision support systems by using advanced algorithms and machine learning to improve diagnostic validity and efficiency [[3](#3542sokm54z)][[4](#u7x8i9xvh9lm)].

All those projects, however, do not leverage the giant technological leap presented by the latest LLM models such as GPT-4 and Gemini-1.5. Until recently, LLMs failed in Theory of Mind (ToM) and social intelligence tests, as shown by Sap et al. (2022) [[5](#q37ksspy4mzs)]. In 2024, the situation is different, as reported by Street et al. [[6](#hcq5nti9hv09)]. LLMs now outperform adults in interpreting social situations, can detect social and unsocial behavior; using audio to speech recognition techniques and NLP, LLMs can understand, analyze, and transcribe conversational dynamics from real-life interactions. This inspired the development of IRIS, an application that leverages AI and NLP within a decision support system (DSS).

With the broad view of assisting autistic children through technology, IRIS provides tools for therapists who teach autistic children how to navigate social situations. Through a comprehensive overview of the child's ongoing social interactions and an iterative feedback mechanism, IRIS will continuously improve and adapt based on real-world data and therapist feedback.

IRIS acts as a reliable witness and documentarian. Triggered by a schedule, specific words, or recognized emotions from conversation analysis, it documents these events and provides therapists with summaries and AI-generated visual stories based on these conversations.

IRIS incorporates speech recognition and natural language processing (NLP) to analyze conversational nuances, as demonstrated in studies by Bone et al. (2014) and Hutchins et al. (2024) [[7](#l833yxorltm8)][[8](#gpfdn8qklq4b)]. Furthermore, mobile augmented reality technologies for ASD interventions, as reviewed by Lian and Sunar (2021), support therapeutic interventions through innovative visual aids [[9](#lcpkqdg42yg1)]. Kozima, Nakagawa, and Yasuda (2005) demonstrated how interactive robots could aid in communication-care for autistic children, inspiring features within IRIS [[10](#6zsnhl18qaxi)].

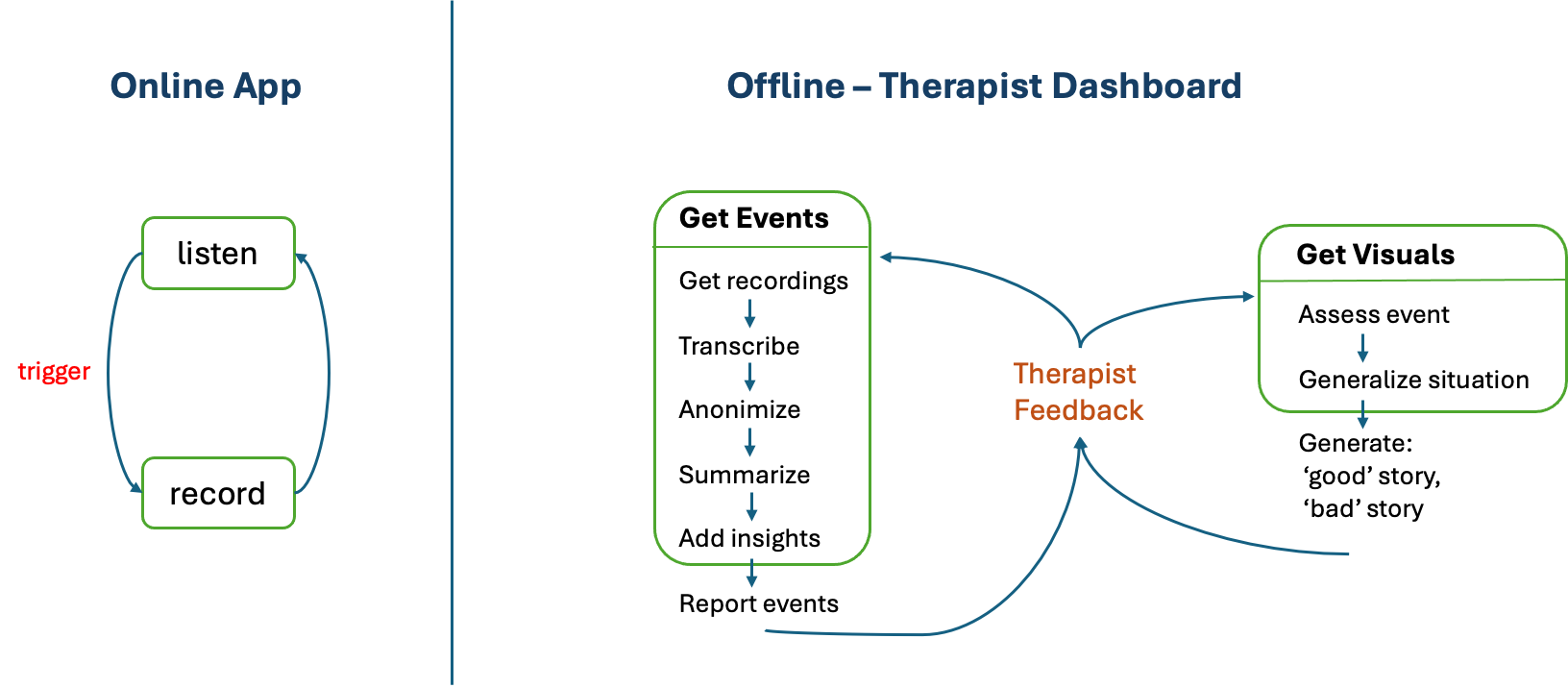
Privacy is crucial in applications handling sensitive personal data, and more so when it comes to children. Price and Cohen (2019) and Torkzadehmahani et al. (2022) emphasized the importance of privacy-preserving AI techniques, which IRIS integrates to maintain stringent security measures [[11](#hy2en3idko66)][[12](#5qgqyrt7lla7)].

Another key consideration is adhering to FAIR principles to ensure data is findable, accessible, interoperable, and reusable [[13](#d0fq9sux6oxi)].

## 

## Methodologies

### System Architecture



*Figure 1 - A diagram of IRIS’s system architecture*

IRIS consists of two AI powered components: an online application that only listens and records events when triggered, and an offline application, the therapist’s dashboard. Via the dashboard, the therapist can: (1) generate a report on the day’s recorded events, and (2) generate visuals for an event. The therapist will provide feedback to each output of the system. The system will use this feedback to improve its accuracy, fine tuning it to the child’s specific needs, as identified by the therapist.

During the training period, IRIS serves as a passive decision support system. Therapists provide feedback on summaries, visual stories, and alternative solutions suggested by IRIS to refine the model. Our vision is for IRIS to evolve into an active, real-time support system for autistic children, acting as a reliable agent on behalf of the therapist.

### Key features and Architecture Considerations

#### AI-Generated Visual Aids

AI creates visual aids depicting generic scenarios based on recorded conversations, helping children generalize social behaviors. This involves analyzing recorded conversations to generate summaries, creating visual stories or videos, and using varied scenarios to teach applicable social solutions, improving children's ability to navigate social interactions effectively.

#### Generalization of the Social Situation

Autistic individuals often struggle with generalizing social skills from one context to another. To address this, IRIS provides therapists with varied scenarios, including conversations and visual aids, that mirror real-life interactions. IRIS will generate additional scenarios based on the recorded conversations, showcasing different settings, participants, and props while maintaining similar social interactions. These synthetically generated scenarios present varied contexts and potential solutions for the same social challenges, aiding autistic children in generalizing their social skills across different situations.

Feedback Mechanisms

Systematic approaches gather, analyze, and integrate feedback from clinicians effectively. Feedback modules within the app interface allow clinicians to provide input immediately after therapy sessions using structured forms, rating scales, and open-ended responses. This feedback is critical in labeling data and fine-tuning the model. Advanced NLP techniques categorize feedback sentiments and analyze usage data, identifying patterns and areas for improvement. Continuous model training and improvement based on feedback outcomes ensure accuracy and responsiveness. Regular updates with new data adapt models to changing user needs. New features are developed based on feedback analysis to enhance the tool’s performance, particularly in handling complex social interactions.

#### Possible Datasets

Possible datasets for the training and fine tuning of the selected LLM may include the National Database for Autism Research (NDAR), which offers a wealth of autism-related data. The ADOS-2 (Autism Diagnostic Observation Schedule, Second Edition) is a standardized diagnostic tool for assessing autism. It includes recorded video sessions between the child and the therapist and can be used to train AI models to understand and interpret autistic behaviors and responses. Given the focus on Hebrew for IRIS's training phase, access to ADOS-2 video conversations from Israel might be necessary. The Child Language Data Exchange System (CHILDES) contains a rich database of child language transcripts, including interactions involving autistic children, which can be translated to Hebrew for training and validation. TalkBank, another comprehensive database of spoken language interactions, includes clinical populations and autism-related subsets that are useful for training and validation. The Stanford Autism and Developmental Disorders Research Program encapsulates various research studies, providing relevant conversational data.

## Expected Results and Key Performance Indicators (KPIs)

To evaluate IRIS's effectiveness, several KPIs are proposed, each assessing different functionality:

### Multi-Participant Conversations - Transcriptions, Summaries and Insights

* **Objective:** Evaluate the model's ability to accurately transcribe and analyze conversations with multiple participants, recognizing the voice and name of the autistic child and capturing emotions in the participants' voices.
* **Method:** Simulate multi-person conversations with diverse speech patterns and behaviors.
* **Expected Results:** Triggering of recording, accurate identification, transcription, summarization and insights from LLM.
* **KPIs:**
  + **Triggering Accuracy:** correct activation of all configured system triggers.
  + **Speaker Attribution Accuracy:** Correct identification of who spoke each statement, especially - who is the autistic child.
  + **Transcription Accuracy:** Percentage of words correctly transcribed.
  + **Summarization Accuracy:** Should be coherent and concise, while still highlighting the gaps in communication if they exist in the conversation.
  + **Insights Relevance and Value:** the LLM should correctly understand the social interaction and highlight problems.
  + **Quality of generalization:** The therapist should give feedback on the various solutions proposed by the LLM for the social situation.

### Multi-Participant Conversations - AI-Generated Visual Aids

* **Objective:** Determine the effectiveness of AI-generated visual aids in teaching children to generalize social behaviors.
* **Method:** Generate and present visual stories from recorded scenarios to observe the application of learned behaviors in new situations. Use feedback from these sessions to label data and refine the AI's ability to create effective visual aids.
* **Expected Results:** Generated visual aids which accurately capture the social situation.
* **KPIs:**
  + **Engagement Level:** Degree of children's interaction with the visual stories.
  + **Social Situation Capturing:** The generated visuals have to capture the overall social situation correctly.
  + **Consistency and Clarity**: The generated visuals should be animated in a naive consistent manner depicting only the relevant characters and items from the conversation.

### Periodical Performance Assessment

* **Objective:** The therapists should be able to assess the progress of the child and the improvement of the model.
* **Method:** Schedule periodical review with therapists.
* **Expected Results:** Both the child and the model show improvement.
* **KPIs:**
  + **Overall child progress**
  + **Child progress attributed to IRIS**
  + **Model improvement over time**

### Challenges in autistic communication - Recognizing and Handling Echolalia

* **Objective:** Assess the model's proficiency in recognizing and handling echolalia (repetition of words or part of words).
* **Method:** Incorporate echolalic speech patterns into test conversations.
* **Expected Results:** Effective recognition and differentiation of repetitive speech from contextually relevant responses, and accurate transcription of the conversation.
* **KPIs:**
  + **Echolalia Detection Rate:** Accuracy in identifying echolalic instances.

### Challenges in autistic communication - Multilingual Conversations

* **Objective:** Test the model's ability to handle conversations with multiple languages.
* **Method:** Conduct multilingual dialogues with frequent switches, e.g., between Hebrew and English.
* **Expected Results:** Accurate transcription and maintenance of conversational context across language switches.
* **KPIs:**
  + **Multilingual Transcription Accuracy:** Correct transcription rate for each language involved.

## Discussion

### FAIRness in IRIS

IRIS adheres to FAIR principles to enhance usability and support for autistic children and caregivers. It ensures data is findable with unique identifiers and detailed metadata, accessible through secure protocols and standardized APIs, interoperable using common data formats like JSON or XML, and reusable with comprehensive documentation and clear licensing to facilitate ethical reuse and protect privacy.

### Regulatory Compliance and Data Privacy

IRIS upholds high data privacy and security standards, aligning with GDPR. This includes integrating privacy from the outset, establishing clear consent mechanisms, and adhering to GDPR principles by collecting only necessary data and allowing users to access or delete their information. Since IRIS also records the autistic child's peers who have not provided consent, privacy is addressed by data masking to replace sensitive information with anonymized values, encrypting all stored and transmitted data, and using secure databases with restricted access and audit trails.

### Open-source vs. Closed-source LLMs

The choice between open-source and closed-source LLMs is critical. Open-source LLMs would ensure maximum privacy, whereas closed-source LLMs are constantly updated and outperform the open-source ones. For IRIS, closed-source LLMs should be used (e.g. Gemini or OpenAI), applying all privacy techniques detailed in the methodologies section.

### Combining Technological, Ethical, and User-Centric Perspectives

IRIS should integrate technology with ethical considerations and user-centered design to support autistic individuals effectively. Ethical considerations are key to any future development. Any such development must preserve the children’s agency and autonomy while keeping them from any harm. Personalized design involves caregivers ensuring the tool meets the specific needs of their patient. Unlike robot-assisted therapies that may disclose a child's autism status, IRIS operates discreetly in the background. Integration with existing therapeutic practices enhances traditional therapies with data-driven insights from the patient’s day-to-day life.

### Future Development and Further Use Cases

IRIS is developed in Israel and will initially record Hebrew conversations, with plans to support English and other languages in the future.

Leveraging on LLMs voice recognition capabilities, we may want to add near real-time notifications which would alert the caregivers of hate or violent speech in the conversations. Alerts may help other populations, including non-autistic children needing social assistance, and individuals with other disabilities who may benefit from alerting their caregivers to real-time danger. IRIS can improve classroom environments by alerting teachers to bullying or negative interactions among students. This proactive approach fosters a safer, more inclusive educational setting, allowing prompt intervention.

Integrating IRIS into augmented reality (AR) smart glasses offers significant potential. AR can provide children with visual and audio cues during social interactions or present a virtual character as a highly trained personal aide to help solve social problems.

To gain trust and adoption among caregivers, therapists, and users, extensive user testing, education, and support are essential.

Additionally, ensuring scalability, particularly in low-resource settings, is crucial for widespread adoption.

With a strong focus on privacy and ethical considerations, future development might involve dedicated hardware and embedded LLM.

IRIS exemplifies how technological innovation, ethical considerations, and user-centric design can enhance decision support in autism care, benefiting both autistic and non-autistic children.

Glossary of Terms and Abbreviations

| **Term/Acronym** | **Description** |
| --- | --- |
| AI | **Artificial Intelligence** - A field of computer science dedicated to the creation of systems capable of performing tasks that normally require human intelligence. |
| DSS | **Decision Support System** - Computer programs that help with decision-making by analyzing large amounts of data to provide comprehensive information. |
| NLP | **Natural Language Processing** - A branch of AI that helps computers understand, interpret, and manipulate human language. |
| LLMs | **Large Language Models** - Advanced machine learning models designed to understand and generate human-like text based on training on vast datasets. |
| ToM | **Theory of Mind** - Our unique ability to reason about what is going on inside other people’s minds, including what they want (desires), what they know (knowledge), and what they think is true based on their prior experience (beliefs). |
| ADOS-2 | **Autism Diagnostic Observation Schedule, Second Edition** - A semi-structured assessment of communication, social interaction, and play. |
| NDAR | **National Database for Autism Research** - A resource provided by the U.S. government containing data for researchers studying autism spectrum disorders. |
| CHILDES | **Child Language Data Exchange System** - A database that archives conversational interactions, focusing on language development in children. |
| TalkBank | A database that provides transcripts, audio and video of structured and unstructured conversations. |
| Personal aide | Assistants who help children with disabilities. |
| Echolalia | The repetition of phrases, words, or parts of words, often observed in autistic individuals. |
| KPIs | **Key Performance Indicators** - Measurable values that demonstrate how effectively a company or project achieves key business objectives. |
| Visual Aids | Resources such as social stories, pictorial schedules, and visual guides designed specifically for autism therapy to aid in teaching social skills and behavioral norms in a structured manner. |
| GDPR | **General Data Protection Regulation** - A regulation in EU law on data protection and privacy. |
| VR | **Virtual Reality** - A simulated experience that can be similar to or completely different from the real world, used in digital applications. |
| AR | **Augmented Reality** - An enhanced, interactive version of a real-world environment achieved through digital visual elements, and sounds. |

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## Appendix

### Recorded Conversation and an Example of the Expected Results

**Scene:** Playground

**Participants:** Alex (Autistic Child), Jamie (Child) and Casey (Child)

**Audio Conversation (transcription):**

1. **Jamie**: *(approaches Alex who is playing alone with blocks)* "Hi Alex, those look cool! Can we build something together?"
2. **Alex**: *(pauses)* "Okay... you can use the red ones."
3. **Casey**: *(joins in)* "Can I play too? I have green blocks!"
4. **Alex**: *(slightly anxious)* "No, only red and blue blocks go together."
5. **Jamie**: *(smiles gently)* "That’s a great idea, Alex! Let’s start with red and blue, and maybe later, we can see if green fits somewhere?"
6. **Alex**: *(relaxes a bit and smiles back)* "Okay, we can try later."

**Prompt to the images generative tool:**

Please create Visual Aid for a Social Story. Make sure the overall meaning of the social situation is kept. This should be 1 image containing 6 distinct images with black borders around them. Make sure each character is represented in the same way along the visual story. All 3 characters should be around the same age but should also be distinguishable from each other.

**Result:** One big image is created, containing 6 different images in the right chronological order:

Image 1: Alex is sitting alone on the ground, focused intently on assembling only red and blue blocks around him.

Image 2: Jamie approaches Alex from the side with a friendly smile, looking at Alex who is concentrating on the blocks. Jamie is motioning towards the blocks as if asking to join.

Image 3: Casey, holding a large green block in both hands, excitedly joins them, looking expectantly at Alex and Jamie.

Image 4: Alex looks up at Casey, appearing slightly anxious, while gently shaking his head no. Alex’s attention is on Casey’s green block.

Image 5: Jamie is smiling reassuringly at Alex while gesturing towards the blocks they're playing with. Alex looks thoughtful, considering Jamie’s words. Casey watches both, holding the green block at his side.

Image 6: All three children are on the ground around a growing tower of red and blue blocks. The green block is set to the side, visible but not yet part of the structure. Jamie and Casey are both placing blocks on the tower, while Alex watches, deciding if the green block could fit.

### Generalization of the Situation from the Recorded Conversation

Speech therapists working with autistic children need to provide varied scenarios to help patients generalize social skills. Following are two additional scenarios generated by IRIS, based on the original real-life recorded playground conversation, but featuring different settings, participants, and props. These newly generated scenarios also suggest slightly different solutions to the social problem. By obtaining therapists’ feedback on each generated social problem and solution, we create additional labeled data to fine-tune our model.

#### Scenario 1: Art Class

**Scene: Art Classroom**

**Participants: Alex** (Autistic Child), **Maya** (Child) and **Leo** (Child)

**Audio Conversation:**

1. **Maya**: "Hey Alex, want to paint a picture together?"
2. **Alex**: "Okay. I like using red and blue paint."
3. **Leo**: "Can I join too? I want to use yellow paint!"
4. **Alex**: "No, yellow doesn't fit with red and blue."
5. **Maya**: "How about we paint with red and blue now, and then we can use yellow for the background later?"
6. **Alex**: "Alright, that sounds good."

**Visual Aids for Social Story:**

* **Image 1**: Alex is sitting at a table with red and blue paint, focused on his painting.
* **Image 2**: Maya approaches Alex from the side with a friendly smile, holding a paintbrush.
* **Image 3**: Leo joins with a big smile, holding a jar of yellow paint.
* **Image 4**: Alex looks at Leo, appearing unsure, while pointing to his painting.
* **Image 5**: Maya smiles reassuringly at Alex while holding a brush with red paint. Alex looks thoughtful, considering Maya’s words. Leo stands beside them, holding the yellow paint.
* **Image 6**: All three children are painting together, with Maya and Alex using red and blue, and the yellow paint set aside for later use.

#### Scenario 2: Building Sandcastles

**Scene: Beach**

**Participants: Alex** (Autistic Child), **Sam** (Child) and **Ella** (Child)

**Audio Conversation:**

1. **Sam**: "Hi Alex, can we help you build a sandcastle?"
2. **Alex**: "Sure. We can use these red and blue buckets."
3. **Ella**: "I have a green bucket. Can I use it too?"
4. **Alex**: "No, only red and blue buckets."
5. **Sam**: "How about we take turns using the green bucket?"
6. **Alex**: "Okay, we can take turns."

**Visual Aids for Social Story:**

* **Image 1**: Alex is sitting on the sand, using red and blue buckets to build a sandcastle.
* **Image 2**: Sam approaches with a smile, holding a red bucket.
* **Image 3**: Ella joins with a smile, holding a green bucket.
* **Image 4**: Alex looks at Ella, appearing uncertain, while gesturing to his sandcastle.
* **Image 5**: Sam smiles reassuringly at Alex while pointing to the buckets. Alex looks thoughtful, considering Sam’s suggestion. Ella stands beside them, holding the green bucket.
* **Image 6**: All three children are building the sandcastle together, taking turns with the green bucket.