KATbot

Team B0:
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Application Area

Storytelling robot that interacts with people to aid in language and reading comprehension

- Merging AI with educational tools
- Target Audience: early elementary school aged children
- Child-friendly user experience

Solution Approach

Speech Processing & Text to Speech: Convert speech to ML input and ML output to speech

1. Text to speech dialogue prompts user for input
2. User speech is processed and sent to the ML model
3. ML model returns the rest of dialogue

Robot: Custom-made robot inspired by Japanese lucky cats

1. Robot houses all electronics needed for project
2. 2x one degree of freedom robot arms
3. Text display to display current sentence
4. Face display

Storytelling Algorithm: receive user's input word, output sentence by sentence to TTS

1. Start with manually configured template, keywords removed
2. Prompts user for part of speech
3. User input goes through error detection and grammar correction
4. Algorithm predicts dependent words to customize the story
   a. Synonym/Antonym generation
   b. FitBert to fill in the blanks

System Diagram
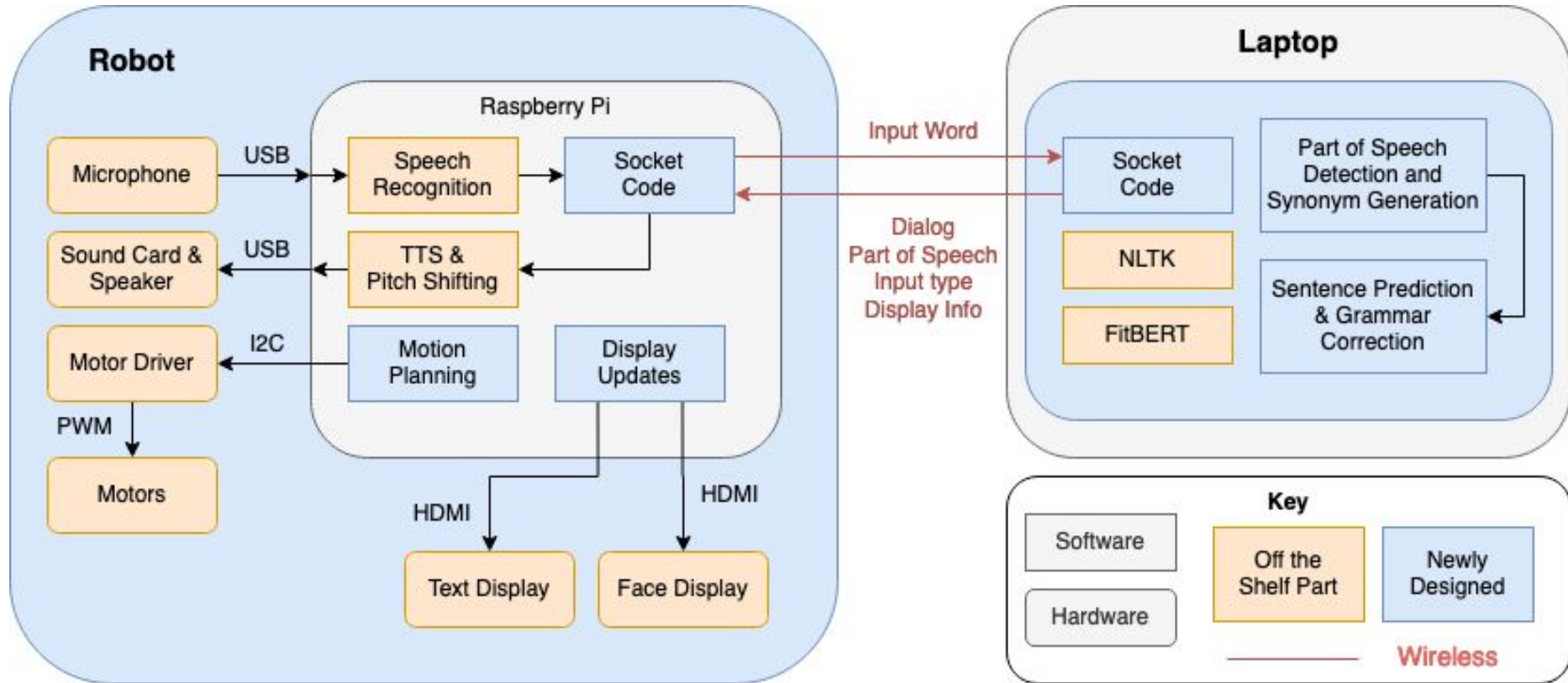
Solution Video

Design Tradeoffs

Synonym Generation: ML vs Internet
- Latency study: 10 word synonyms, 10 word antonyms
- **NLTK synonym generation:** 64.072% accuracy relative to online thesauruses, 0.07274 s latency
- Online thesauruses:
  - **Thesaurus.com:** 100% results found, 0.38575 s latency
  - **Thesaurus.com + Kid Thesaurus:** 100% results found, 1.82123 s
    - Prioritize more kid-friendly words

Part of Speech Taggers
- Perceptron tagger: 90.83% accurate, 0.00074036 s
- Bigram tagger: 74.60% accurate, 0.00074135 s
- In conjunction: 93.82% accurate, 0.00074017 s

Design Tradeoffs

Robot :
- Cardboard frame and structure
  - No access to 3D printing and laser cutting
  - Convenient, but looks like a prototype

- Wireless communication
  - Easier to use, more portable

- Large face display vs small eye display
  - Eye display: bigger eyes
  - Face display: includes the mouth (needed to show emotion)

- NXT motors vs servos
  - No access to servos with enough torque
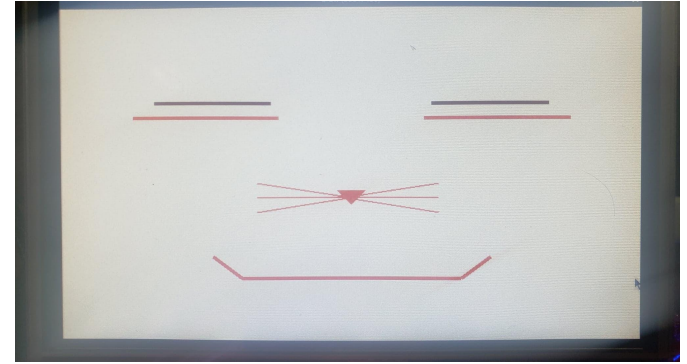
"Happy" face
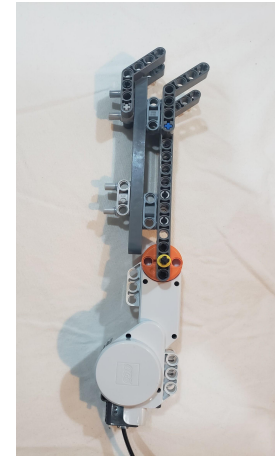
Robot arm frame   Robot arm shell

Metrics and Validation

Description	Goal	Verification Method	Changes?
Part of Speech Error Detection	90% accuracy	Automated SW Testing - top 2 most common POS per word	No
Synonym Recall	85% accuracy	SW Testing - Test Dataset	No
Speech Processing Accuracy	15% Word Error Rate	Measure decoding errors	No
System Latency	4 - 6 sec	Time user i/p to speech o/p	**Not required**
Power	30 - 45 min	User testing	**Not required**

Metrics and Validation

Description	Goal	Verification Method	Changes?
Story Cohesion	Cohesion level falls between original stories and random stories	User survey - grade three types of stories based on 5 variables: *Logical Sense, Themes, Genre, Narrator, Style*	No
User Satisfaction	- Liked the stories (87.5%) - Wanted to play again (100%) - Robot was friendly (87.5%) - Robot's stories were interesting (87.5%) - Robot's stories were understandable (100%)	User Survey	**Measured, but goals relaxed**

Story Metrics

Description	Goal	Results	Passed?
Part of Speech Error Detection	90% accuracy	93.82% accuracy	**YES**
Synonym Recall	85% accuracy	100% accuracy	**YES** - irrelevant with new design
Story Cohesion	Cohesion level falls between original stories and random stories	Logical Sense (0-10): Random = 1.6 **KATbot = 4.0** Original = 8.4 Total Score (0-50): Random = 22.2 **KATbot = 29.0** Original = 42.0	**YES**

Speech and Whole System Metrics

Description	Goal	Results	Passed?
Speech Processing Accuracy	85% accuracy	87.7% accuracy	**YES**
System Latency	4 - 6 sec	User Input: 4.90 sec No User Input: 2.56 sec	**YES**
User Satisfaction	- Liked the stories (87.5%) - Wanted to play again (100%) - Robot was friendly (87.5%) - Robot's stories were interesting (87.5%) - Robot's stories were understandable (100%)	- Liked the stories (90.5%) - Wanted to play again (90.5%) - Robot was friendly (76.2%) - Robot's stories were interesting (90.5%) - Robot's stories were understandable (85.7%)	**MIXED RESULTS** - within 15% of original metrics

Project Management

TASK TITLE	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13
Dates	2/3/2020	2/10/2020	2/17/2020	2/24/2020	3/2/2020	3/9/2020	3/16/2020	3/23/2020	3/30/2020	4/6/2020	4/13/2020	4/20/2020	4/27/2020
--> Audio input/output												Ashika	
--> Speech processing package												Jade	
--> Story generation pipeline + algorithm												Abha+Ashika	
--> Robot design												Abha+Jade	
--> Communication protocols												Ashika+Jade	
Evaluate solution approaches												Everyone	
Design & Build MVP Parts													
System Architecture Diagram													
System interaction design													
Hardware Benchmarks and Metrics													
Software Benchmarks and Metrics													
Write Design Document													
Prepare for Design Presentation													
Bill of Materials/Order Parts													
Raspberry Pi Setup/Installs													
Prototype of Speech/TTS on laptop													
Speech Processing/TTS on RPi													
Raspberry Pi to Laptop Comms													
Communication Protocols													
Text display													
Face display													
Robot arms design													
Robot arms manufactuing													
Path Planning for arms													
Robot shell design													
Robot shell manufacturing													
Robot shell integration													
ML dataset gathering													
Part of speech tagging													
--> Error detection for user input													
--> Synonym detection													
--> Template making													
Fill in the blank													
User Program													
ML story generation unit testing													
Integration and Testing													
Audio input to ML algorithm													
Robot displays text from ML algorithm													
Robot text to speech													
Design Evaluation & Improvement													
Whole system testing													
Design evaluation													
Improvements													
Final system testing													
Prepare for Final Presentation													
Demo Video													
Final Report													