June 12, 2024

Middle Tennessee State University

Understanding Embodied Robotics Learning Using Video Based LLM Methods

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Electronic Conference On Teaching Statistics (eCOTS 2024), Belmont University

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Research Background & Motivation

- Embodied learning involves using the body as a tool for learning, making abstract concepts more tangible.
  - Important in fields like robotics, hands-on experiences can significantly enhance effectiveness of learning.
  - Emphasizing the integration of physical movement with cognitive processes to improve knowledge retention.
  - Enhancing engagement and motivation by making learning more interactive and enjoyable.

Image created by Open AI

Goal

- To enhance the understanding of robotics concepts through embodied learning by comparing embodied videos related to robotics with conventional videos, ultimately improving educational outcomes in robotics education.

Image created by Open AI

Research Objectives

- To assess whether hands-on, embodied learning videos **elicit more** user comments and a higher level of engagement compared to conventional videos.
- To **systematically** research and document the benefits of embodied learning in robotics education by extracting and analyzing user comments from both types of videos using a Large Language Model (LLM) for sentiment analysis.
- To **compare the sentiment distribution** (positive, negative, neutral) between comments on embodied learning videos and conventional learning videos in robotics education.

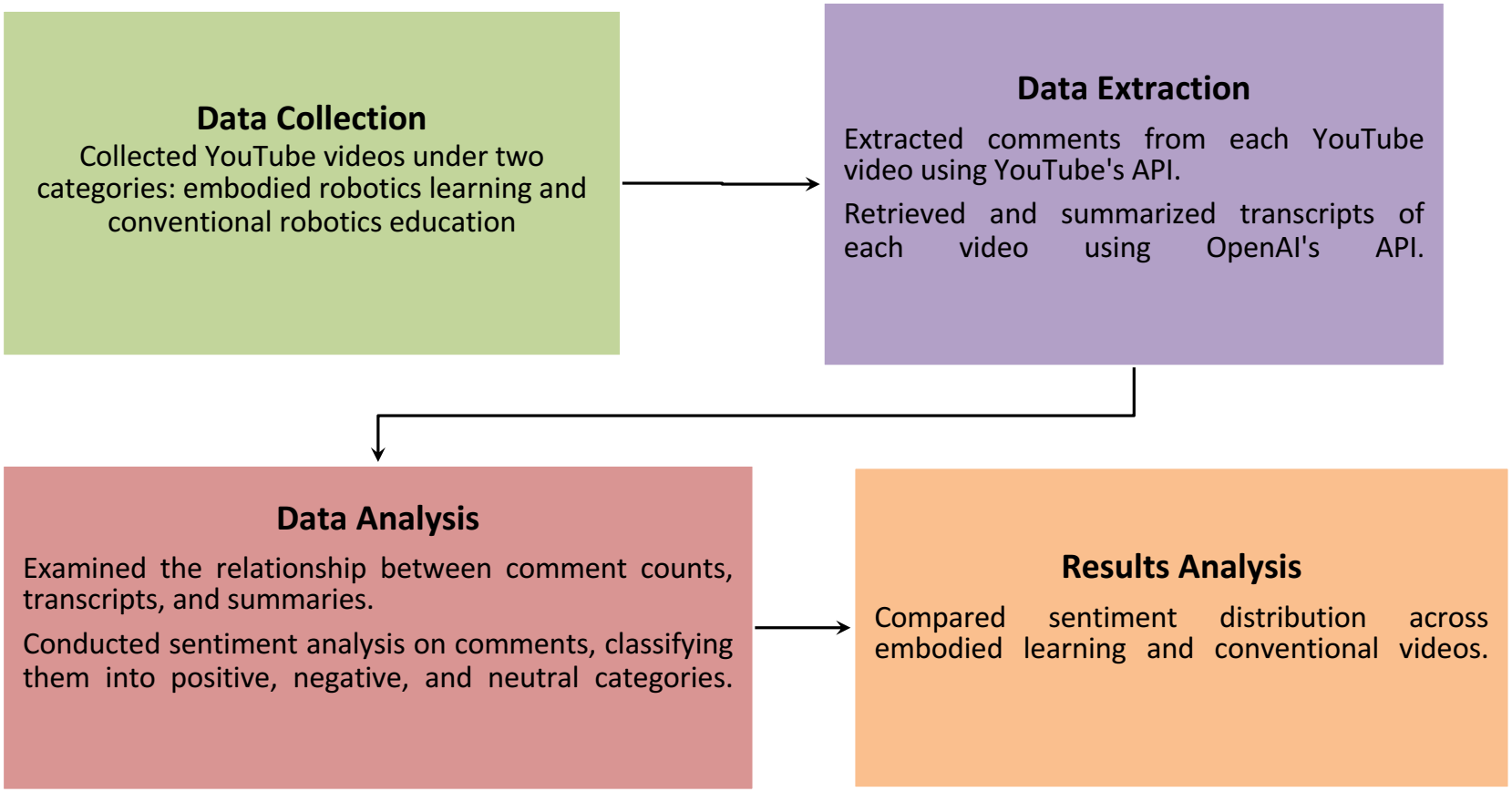
Literature Review

Aspect	Details	References
Embodied Learning in Education	Definition: Utilizing physical activities to facilitate learning, making abstract concepts more tangible.	Johnson-Glenberg et al., 2014
	Significance:	
	- Enhances cognitive processing by integrating sensorimotor experiences.	Shapiro & Stolz, 2019
	- Improves engagement and motivation by making learning interactive and enjoyable.	Kontra et al., 2015
	- Better understanding and retention of complex concepts through physical interaction.	
Impact on Engagement and Sentiment	**Student Engagement:**	Chi & Wylie, 2014
	- Active learning environments lead to deeper engagement and better academic outcomes.	Dede, 2014
	- Technologies like robotics can make learning more immersive and interactive.	
	Sentiment Analysis:	Liu, 2012
	- Gauges public opinion and emotional responses to improve learning experiences.	Poria et al., 2018
Comparative Studies on Learning Formats	Embodied vs. Conventional Learning:	Freeman et al., 2014
	- Students in active learning environments perform better than those in traditional lecture-based settings.	Lindgren & Johnson-Glenberg, 2013
	- Higher levels of student satisfaction and positive emotional responses are observed in embodied learning settings.	

Literature Review (Contd...)

Aspect	Details	References
Use of Large Language Models (LLMs) in Education	Sentiment Analysis Using LLMs:	Radford et al., 2019
	- LLMs like GPT-3 analyze large datasets of text, providing insights into sentiment and engagement.	Devlin et al., 2018
	- State-of-the-art results in sentiment analysis tasks, making them suitable for educational content analysis.	
Practical Applications and Outcomes	Robotics Education:	Mataric, 2004
	- Robotics provides hands-on, interactive learning experiences that align with principles of embodied learning.	Belpaeme et al., 2018
	- Increases engagement and motivation in educational contexts, particularly when used in an embodied learning approach.	
Embodied Learning and Sentiment Analysis	Systematic Research: Analyzing the impacts of embodied learning using sentiment analysis techniques to evaluate student engagement and emotional responses in educational videos.	Johnson, S. A., & MacLean, K. (2023). "Impact of embodied learning on student engagement and sentiment in educational videos." Journal of Educational Technology, 39(3), 234-245.

Methodology



Data Collection

- To evaluate the impacts of embodied learning on student engagement and sentiment by comparing data from YouTube videos related to embodied and conventional types.

  - Video Selection: 100 YouTube videos selected in the robotics domain.
    - 50 videos **with** embodied (hands on) learning components.
    - 50 videos **without** embodied (conventional) learning components.

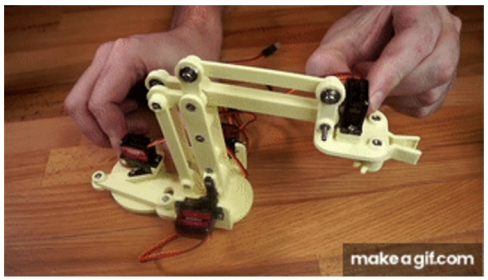


Fig 1. Embodied

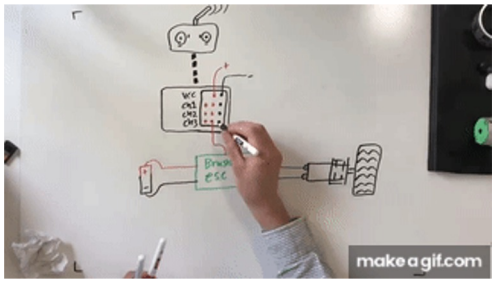


Fig 2.Conventional

Research Part 1

Video Transcription, Summarization, Comment Extraction

Correlation of Comments with Transcripts and Summary

Embodied Learning

- Students physically interact with robots, manipulate components, and engaging in hands-on activities to facilitate learning.
- Key aspects include:
  - **Physical Interaction**
  - **Hands-on Activities**
  - **Enhanced Engagement**
  - **Practical Understanding**

Embodied Learning Sample

- **Physical Interaction**: Engage physically by constructing the robotic arm, which involves assembling various components and configuring the system to respond to hand gestures.

- **Hands-on Activities**: The tutorial provides step-by-step instructions on how to build and program the robotic arm, allowing learners to follow along and actively participate in the creation process.

- **Enhanced Engagement**: The interactive nature of the tutorial, including the ability to control the robotic arm wirelessly and perform basic functions autonomously, keeps viewers engaged and interested.

- **Practical Understanding**: By physically building and operating the robotic arm, learners gain a practical understanding of robotics concepts such as hand gesture recognition, wireless communication, and autonomous functionality.

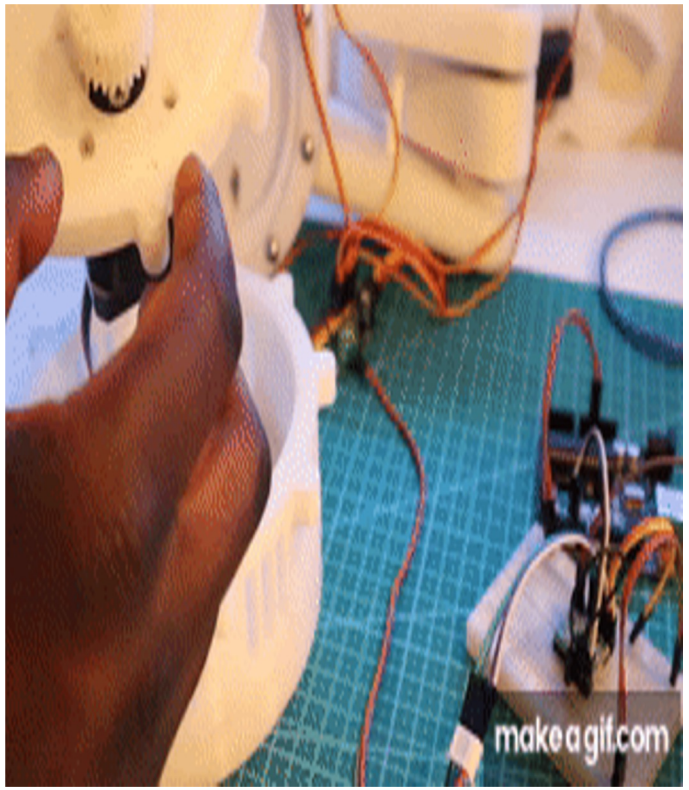


Fig 3. Embodied learning sample
Source:https://www.youtube.com/watch?v=F0ZvF-FbCr0

Non-Embodied Learning (Conventional)

- **Non-embodied/conventional learning** involves more traditional educational methods that do not require physical interaction with the learning material.
- Key aspects include:
  - **Theoretical Instruction**: Learning through lectures, readings, and theoretical discussions.
  - **Visual and Auditory Learning**: Using videos, diagrams, and spoken explanations.
  - **Limited Physical Interaction**: Minimal or no hands-on engagement with actual robotic systems.
  - **Focus on Cognitive Understanding**: Emphasis on understanding concepts and principles through mental processes rather than physical experience.

Non- Embodied Learning Sample

- **Theoretical Instruction**: Viewers receive detailed explanations about the common electronics used in building combat robots, starting from basic setups to more complicated configurations.
- **Visual and Auditory Learning**: The tutorial explains concepts verbally and visually, such as salvaging electronics from toys or buying an RC system, and provides guidance on choosing and setting up motors and controllers.
- **Limited Physical Interaction**: While the tutorial provides instructions, it does not involve viewers physically constructing the robot in real-time during the video.
- **Focus on Cognitive Understanding**: The emphasis is on understanding the principles of RC systems, motor options, and safety requirements through mental processing rather than hands-on activities.

This example illustrates how non-embodied learning relies on theoretical knowledge and cognitive understanding, without the immersive physical involvement characteristic of embodied learning.

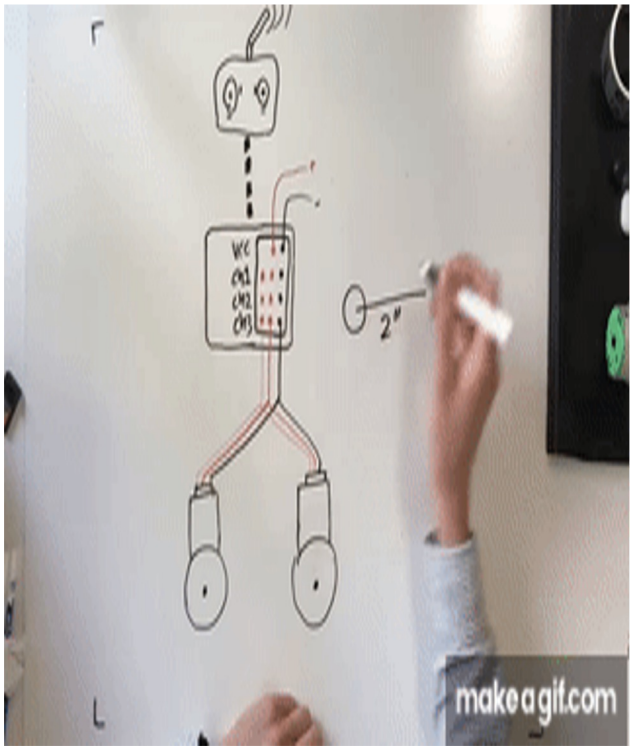


Fig 4. Non -Embodied learning sample
Source:https://www.youtube.com/watch?v=WiJyD3viOOs&t=470s

Comment Extraction in JSON format

```
!pip install youtube-comment-downloader

Collecting youtube-comment-downloader
  Downloading youtube_comment_downloader-0.1.76-py3-none-any.whl (8.2 kB)
Collecting dateparser (from youtube-comment-downloader)
  Downloading dateparser-1.2.0-py2.py3-none-any.whl (294 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 295.0/295.0 kB 3.5 MB/s eta 0:00:00
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from youtube-comment-downloader) (2.31.0
Requirement already satisfied: python-dateutil in /usr/local/lib/python3.10/dist-packages (from dateparser->youtube-comment-
Requirement already satisfied: pytz in /usr/local/lib/python3.10/dist-packages (from dateparser->youtube-comment-downloader)
Requirement already satisfied: regex!=2019.02.19,!=2021.8.27 in /usr/local/lib/python3.10/dist-packages (from dateparser->yo
Requirement already satisfied: tzlocal in /usr/local/lib/python3.10/dist-packages (from dateparser->youtube-comment-downloa
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests->youtube-c
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->youtube-comment-downl
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests->youtube-comment
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests->youtube-comment
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil->dateparser->youtub
Installing collected packages: dateparser, youtube-comment-downloader
Successfully installed dateparser-1.2.0 youtube-comment-downloader-0.1.76
```


{"cid": "Ugy8wWwqY46Zqd8l6KV4AaABAg", "text": "This video alone made me subscribe. I too want to build an army. I have the technology but I do not have the software. I'm clueless", "time": "12 days ago", "author": "@Firebadbob", "channel": "UCP_zu4oS6yPTzG5WizGTtig", "votes": "0", "replies": "", "photo": "https://yt3.ggpht.com/ytc/AIdro_mjzzlBgOJguidWAqEx5l6ZGz1Q20oQBB1j1hpSLIpe6Pg=s88-c-k-c0x00ffffff-no-rj", "heart": false, "reply": false, "time_parsed": 1713497176.155825}


```
pip install https://github.com/egbertbouman/youtube-comment-downloader/archive/master.zip

Collecting https://github.com/egbertbouman/youtube-comment-downloader/archive/master.zip
  Downloading https://github.com/egbertbouman/youtube-comment-downloader/archive/master.zip
     \ 11.8 kB 31.1 MB/s 0:00:00
  Installing build dependencies ... done
  Getting requirements to build wheel ... done
  Preparing metadata (pyproject.toml) ... done
Requirement already satisfied: dateparser in /usr/local/lib/python3.10/dist-packages (from youtube-comment-downloader==0.1)
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from youtube-comment-downloader==0.1) (2
Requirement already satisfied: python-dateutil in /usr/local/lib/python3.10/dist-packages (from dateparser->youtube-comment-
Requirement already satisfied: pytz in /usr/local/lib/python3.10/dist-packages (from dateparser->youtube-comment-downloader=
Requirement already satisfied: regex!=2019.02.19,!=2021.8.27 in /usr/local/lib/python3.10/dist-packages (from dateparser->yo
Requirement already satisfied: tzlocal in /usr/local/lib/python3.10/dist-packages (from dateparser->youtube-comment-download
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests->youtube-c
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->youtube-comment-downl
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests->youtube-comment
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests->youtube-comment
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil->dateparser->youtub
Building wheels for collected packages: youtube-comment-downloader
  Building wheel for youtube-comment-downloader (pyproject.toml) ... done
  Created wheel for youtube-comment-downloader: filename=youtube_comment_downloader-0.1-py3-none-any.whl size=8139 sha256=72
  Stored in directory: /tmp/pip-ephem-wheel-cache-1vyobu_3/wheels/9e/c2/50/6edcbc241706b37274c22aad4ab021dbb5f49ef09a8b0cd47
Successfully built youtube-comment-downloader
Installing collected packages: youtube-comment-downloader
  Attempting uninstall: youtube-comment-downloader
    Found existing installation: youtube-comment-downloader 0.1.76
    Uninstalling youtube-comment-downloader-0.1.76:
      Successfully uninstalled youtube-comment-downloader-0.1.76
Successfully installed youtube-comment-downloader-0.1


!youtube-comment-downloader --url  --output comments.json


usage: youtube-comment-downloader [--help] [--youtubeid YOUTUBEID] [--url URL] [--output OUTPUT]
                                  [--pretty] [--limit LIMIT] [--language LANGUAGE] [--sort SORT]
youtube-comment-downloader: error: argument --url/-u: expected one argument


Double-click (or enter) to edit


!youtube-comment-downloader --url "https://www.youtube.com/watch?v=_M6yqhDTL3k" --output "13.Future of Robotic Manipulation .jsc


Downloading Youtube comments for https://www.youtube.com/watch?v=_M6yqhDTL3k
Downloaded 4 comment(s)
[1.32 seconds] Done!
```

Conversion from JSON to Text format

In [5]:
```
import json

# Set the path to the JSON file
file_path = "/Users/reshmarajan/Desktop/youtube videos/CONVENTIONAL VIDEO/13.Future of Robotic Manipulation .json"
output_path = '/Users/reshmarajan/Desktop/youtube videos/CONVENTIONAL VIDEO/video_13_extracted_comments.txt'

# Open the file and process each line
with open(file_path, 'r') as file, open(output_path, 'w') as output_file:
    for line in file:
        # Parse the JSON data from the line
        json_data = json.loads(line.strip())

        # Extract the 'text' field
        text = json_data['text'].strip()

        # Remove any internal newlines within the text to maintain paragraph integrity
        text = ' '.join(text.splitlines())

        # Write the extracted text to the output file followed by two newlines for spacing
        output_file.write(text + '\n\n')

print(f"Extraction complete. Comments and replies saved to: {output_path}")
```

```
Extraction complete. Comments and replies saved to: /Users/reshmarajan/Desktop/youtube videos/CONVENTIONAL VIDEO/vi
deo_13_extracted_comments.txt
```

Embodied Comments - Sample

hey i am building my own robot eye and i want it to move are these servo motor good

Hello, can you please make this project public in tinkercad?

Hi Eben, I love your videos. Can I check on what books did you use to read and learn about arduino and raspberry pi? I would like to learn more as well. Would love to see the robot do some object detection! I'm currently learning to use arduino and will try to pick up on raspberry pi as well. thanks for the videos! Shoutout from Singapore! Stay awesome.

this is great thanks for the list of parts

Very awesome and easy to understand - Thanks!

Great job man. Keep going✊🏿✊🏿✊🏿

😍😍😍😍😍😍😍 cooooooooooool super cooooooool I have to build one

so dope! Would love to try it

You're amazing. Thank you for these videos. You've inspired me to start creating. Sincerely.
Wow

Non-Embodied Comments - Sample

Such an amazing video!! Thank you for such great beginner info :D

just started in combat robots and this video was very helpful :)

Great information fella!

So can you briefly explain the coding for this

Controller = The T4A makes a good backup transmitter or a take anywhere unit. Drop it, scratch it, leave it in the car and forget about it. This is what the T4A is all about. Not suitable for the multi flapperon, mixer, vtail, FPV, robot controlling hobbyist.

how can you build a battlebot flipper using servo motors? thank you

I ordered the transmitter you have linked but it says there is no way to program it, how are you able to?

How i mix the chanels in an ifly 6

What kind of kits do you suggest?

Good video was wondering where to start since one of my dreams was to make a full size battle bot but this is helpful for making my first and understanding

I need more information about the ESCs. Should I buy 2 ESCs for single or 1 for dual engine? What does "with and without brake" mean? Which one should I buy? What 10A, 20A, 30A means?

Succinct, informative, and clearly illustrated. This helped me visualize a lot of concepts I've read about, and made it seem so much more attainable. Thanks for the video! I'm saving it for future reference.

Transcription Using Open AI’s Whisper Model

- Utilized OpenAI's Whisper model for accurate and efficient transcription of audio content.
- The model is built for automatic speech recognition (ASR)

- **Advantages of Using Whisper:**

  High accuracy in recognizing and transcribing speech from various audio sources.

  Supports multiple languages, making it versatile for different transcription needs.

  Open-source and actively maintained, ensuring continuous improvements and support.

Transcription Sample

Hello, welcome! If you would like to build an antweight or beetleweight combat robot and you don't have any experience with RC systems, then this video is for you. I'm going to explain the common electronics used, starting from the basics to more complicated setups. Hopefully, this serves as a beginner tutorial so you can wire your robot up.

Your first choice in terms of electronics is whether to salvage them from a toy or buy an RC system. If you're brand new to this, salvaging the electronics and the remote from a toy can be a great option. You'll want to look for two things: tank drive (push both thumb sticks forward to go forward, unlike rack and pinion steering in RC cars) and selectable frequencies (labeled on the car as 27 GHz or 49 GHz, or simply as 1 and 2). Avoid small infrared remotes used for hex bugs.

If you choose this option, first take the toy apart. You'll find a circuit board, battery, and wires leading to the motors. Remove the toy's motors and connect these wires to whatever motors you want. This setup is straightforward as your electrical setup is already done for you, and you just need to attach your motors. I recommend gm3 solarbotic gear motors as a starting option. If the motor spins the wrong way, just reverse the leads to change the direction of the DC motor. Note that RC toys won't meet safety requirements for having a weapon, so you're limited to a wedge bot.

Summarization

- YouTube Video Summarizer: Python application that allows you to summarize the content of a YouTube video using OpenAI's GPT-3.5 language model and Langchain.

- The application get the transcription provided by YouTube, chunks the Transcription with Langchain and generates a summary in the language of the youtube video.

- Built with Streamlit for an easy-to-use web interface

- Python 3.6 or above
- Streamlit
- PyTube
- OpenAI
- python-dotenv
- youtube-transcript-api
- Langchain
-

Summarization: How it Works??

1. **Import Libraries and Set Up Environment**:
   - Use os, openai, streamlit, youtube_transcript_api, langchain.text_splitter, and dotenv libraries.
   - Load OpenAI API key from .env file.
2. **Fetch YouTube Transcript**:
   - Extract video ID from the provided YouTube URL.
   - Attempt to retrieve manually created transcript; fall back to auto-generated transcript if necessary.
   - Combine transcript parts into a full transcript and determine the language code.
3. **Summarize Transcript**:
   - Split the transcript into manageable chunks using RecursiveCharacterTextSplitter.
   - Prepare a prompt for summarization, including the language code and structure requirements (introduction, bullet points, conclusion).
   - Use OpenAI's GPT-3.5-turbo model to generate the summary.
4. **Streamlit User Interface**:
   - Create a simple web interface with Streamlit.
   - Allow users to input YouTube video link.
   - Display progress and status updates during transcript retrieval and summarization.
   - Show the final summarized text to the user

Summarization – Output Sample

Title: Beginner's Guide to Building Combat Robots with RC Systems

INTRODUCTION: Are you interested in building an antweight or beetleweight combat robot with RC systems but are new to the process? This summary will provide an overview covering common electronics, options for beginners, and how to wire up your robot for your journey into combat robotics.

BULLET POINTS:

Salvaging electronics from a toy with tank drive and selectable frequencies can be a good entry point for beginners to build their combat robot.

RC toys have limitations in meeting safety requirements for advanced features like weapons.

Buying an RC system entails selecting a 2.4 GHz transmitter with channel mixing options for controlled movement.

Options for powering and controlling your robot's functions include servos, continuous rotation servos, DC gear motors with electronic speed controllers, and powerful brushless motors typically for weapons use.

Regulatory aspects, torque needs, safety concerns, modifying servos, and connecting batteries are noteworthy when choosing equipment.

Practices such as channel mixing for synchronized motor control and wiring setup differences for various types of robots need consideration.

CONCLUSION: By understanding and implementing the basics of RC systems, you can create your combat robot with the right combination of electronics and ensure seamless operation in combat situations. Take these steps to initiate your robot-building journey and unleash your creativity in the competitive world of combat robotics.

Co-relation of comments with Transcript and summary

- Analysis of user comments by correlating them with video transcripts and summaries.
- It uses the OpenAI API to find correlations between comments and video content, helping to understand viewer feedback and engagement.
- Script reads Word documents, processes comments in manageable chunks, and checks for meaningful matches.
- Automated process saves time and provides valuable insights into how well the video content is being received and understood by viewers.

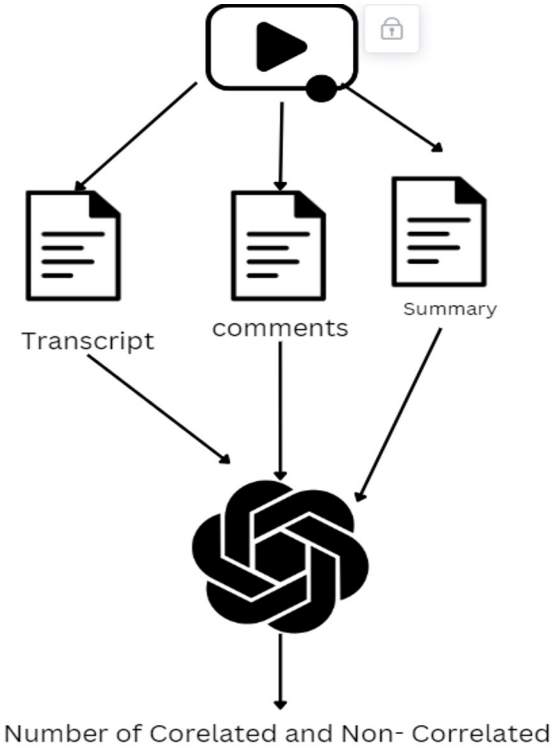
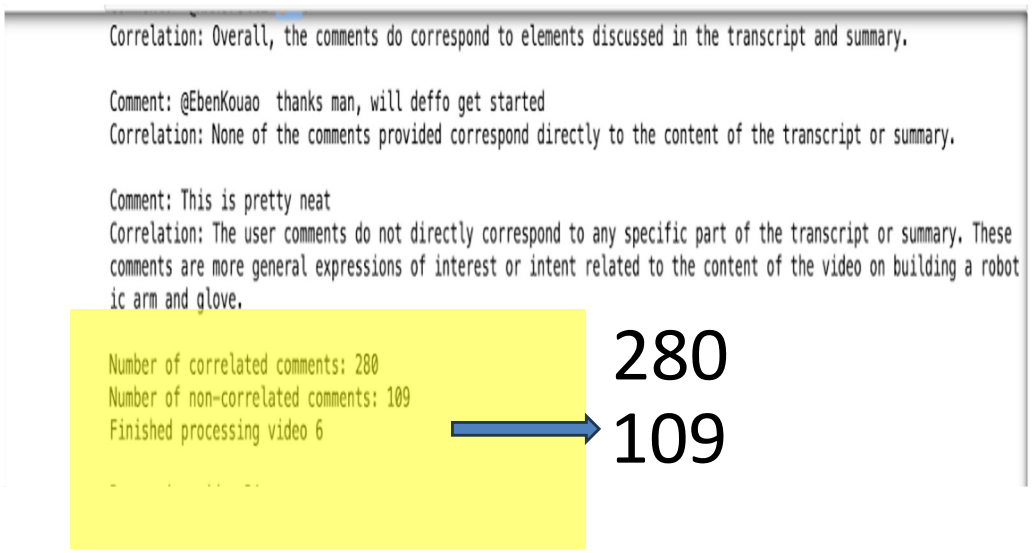


Fig 5. Flow chart demonstrating the correlation of comments with transcript and summary

Results- Co-relation of comments with Transcript and summary



280

109

Embodied Video

Comment: If u have two esc for brushed motors do u need two battery to power the two esc?
Correlation: The comment corresponds to the explanation in the transcript where it mentions brushed DC gear motors paired with electronic speed controllers (ESCs). The speaker explains that many ESCs have a battery elimination circuit (BEC) built-in, so once connected, the receiver doesn't need an extra battery. Some brushed ESCs can power two motors, which is convenient for controlling both the right and left drive motors. Therefore, if using two ESCs for brushed motors, you do not necessarily need two separate batteries to power them.

Comment: What's the best tank drive play toy with both joysticks
Correlation: The comment "What's the best tank drive play toy with both joysticks" corresponds to the part of the transcript where it mentions salvaging electronics from a toy with tank drive and selectable frequencies. This correlates with the information provided in the transcript about looking for a toy with tank drive (push both thumb sticks forward to go forward) and selectable frequencies labeled on the car as 27 GHz or 49 GHz, or simply as 1 and 2.

Number of correlated comments: 34

Number of non-correlated comments: 94

34

94

Non-embodied

Research Part II

Sentiment Analysis of Comments for Embodied and Non- Embodied learning of Robotics

Sentiment Analysis (opinion mining)

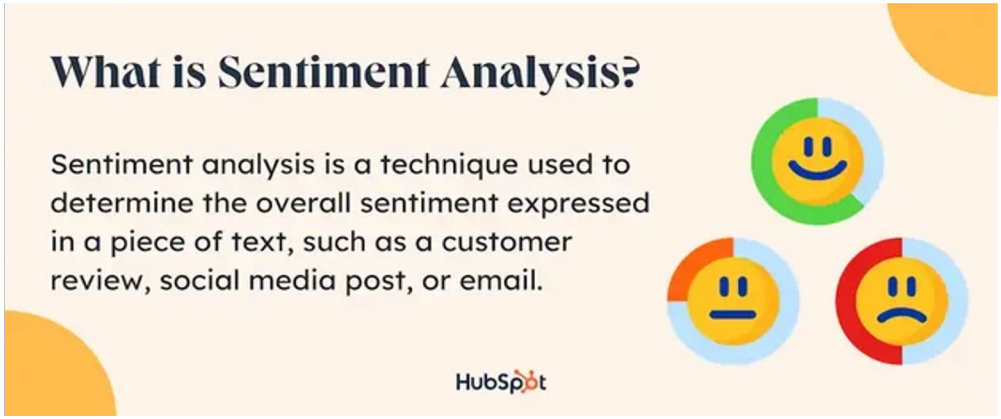


Fig 6. Definition of Sentiment Analysis
Source:https://blog.hubspot.com/service/sentiment-analysis-tools

- **Sentiment Categories:** Positive, negative, and neutral comments.
- **Analysis Tool**: Sentiment analysis algorithms categorized the comments to assess user engagement.

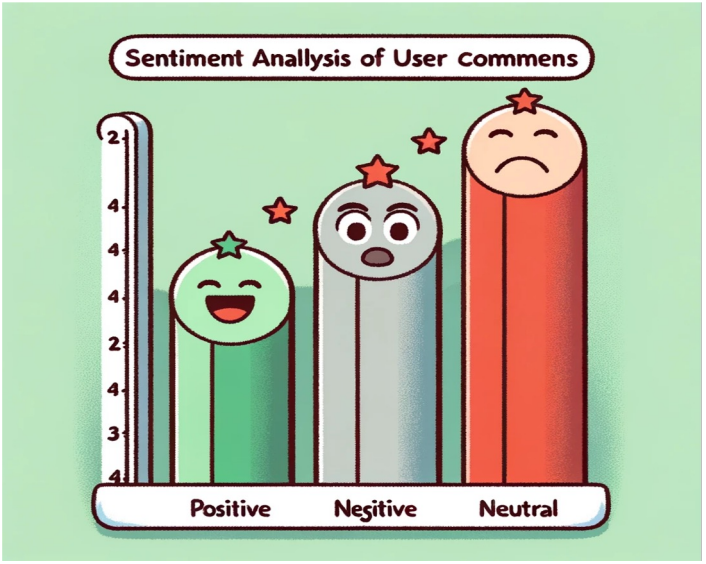


Fig 7. Graphic showing distribution of Positive, Negative, and Neutral Cpmments
Source: Created using Open AI

Sentiment Analysis (opinion mining) (Contd..)

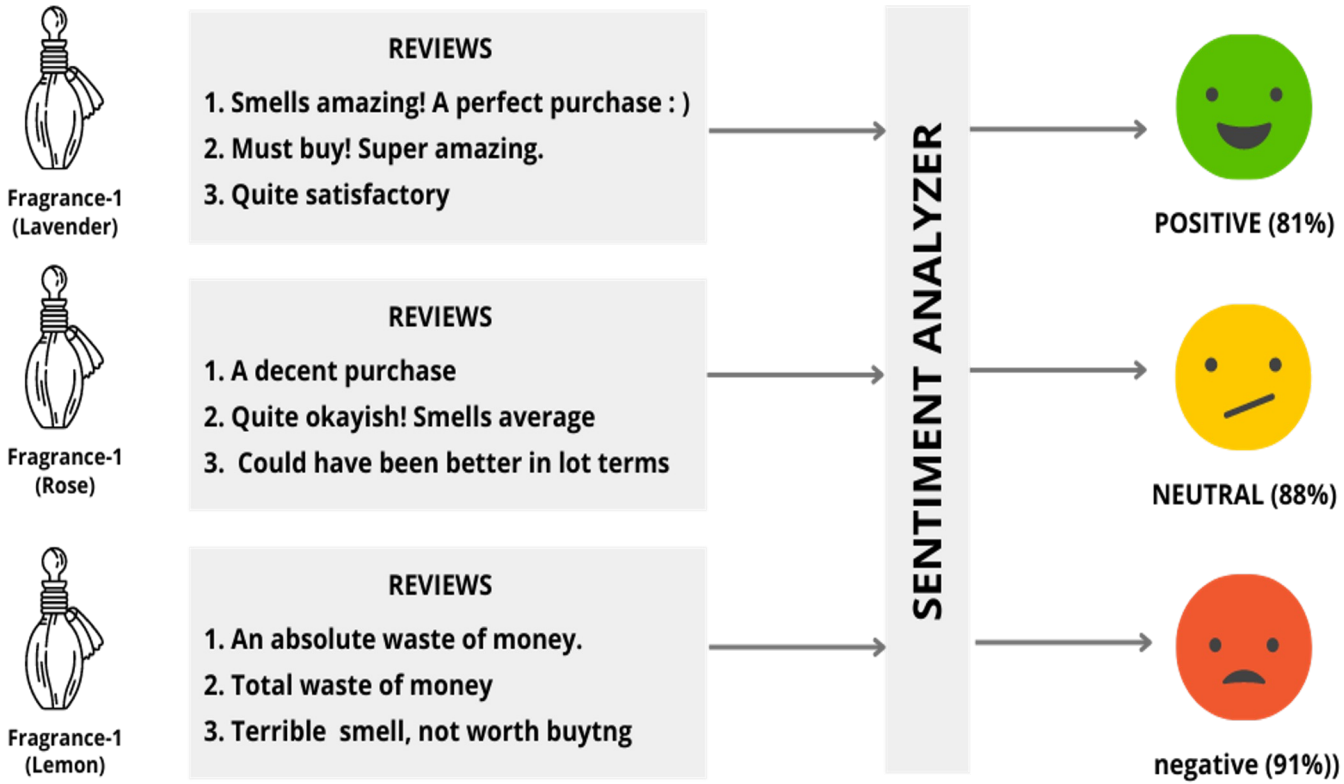


Fig 8. Example of Sentimental Analysis
Source:https://www.analyticsvidhya.com/blog/2022/07/sentiment-analysis-using-python/

Sentiment Analysis: Data Collection

22,581 comments for embodied learning videos.

5,076 comments for conventional learning videos.

Sentiment Analysis: Implementation Code

```
from pysentimiento import create_analyzer
import re

# Create a sentiment analyzer for English text
analyzer = create_analyzer(task="sentiment", lang="en")

# Define the path to the file
file_path = '/Users/reshmarajan/Desktop/youtube videos/CONVENTIONAL
VIDEO/comments_conventional/video_11_extracted_comments.txt'

# Function to split text into paragraphs
def split_paragraphs(text):
    return text.split('\n\n')

# Initialize counters for each sentiment category
total_probabilities = {'NEG': 0, 'NEU': 0, 'POS': 0}
sentiment_counts = {'POS': 0, 'NEG': 0, 'NEU': 0}  # To count the number of sentiments

# Try to open and read the text file
try:
    with open(file_path, 'r', encoding='utf-8') as file:
        text = file.read()
        # Split the text into paragraphs
        paragraphs = split_paragraphs(text)

        # Analyzing each paragraph
        for paragraph in paragraphs:
            if paragraph.strip():  # Check if the paragraph is not just whitespace
                result = analyzer.predict(paragraph)
                print(f"Comment: {paragraph.strip()}\nSentiment: {result.output}, Probabilities:
{result.probas}\n")
                # Accumulate probabilities for overall analysis
                total_probabilities['NEG'] += result.probas['NEG']
                total_probabilities['NEU'] += result.probas['NEU']
                total_probabilities['POS'] += result.probas['POS']
                # Increment sentiment count
                sentiment_counts[result.output] += 1
```

Sentiment Analysis: Implementation Code (Cntd..)

```
        # Calculate the sum of all probabilities for normalization
        total = total_probabilities['NEG'] + total_probabilities['NEU'] + total_probabilities['POS']

        # Normalize each category probability
        overall_probabilities = {
            'NEG': total_probabilities['NEG'] / total,
            'NEU': total_probabilities['NEU'] / total,
            'POS': total_probabilities['POS'] / total
        }

        # Output the overall sentiment probabilities and counts
        print("Overall Sentiment Probabilities:")
        print(f"Negative: {overall_probabilities['NEG']:.4f}")
        print(f"Neutral: {overall_probabilities['NEU']:.4f}")
        print(f"Positive: {overall_probabilities['POS']:.4f}")

        print("\nSentiment Counts:")
        print(f"Positive: {sentiment_counts['POS']}")
        print(f"Negative: {sentiment_counts['NEG']}")
        print(f"Neutral: {sentiment_counts['NEU']}")

    except FileNotFoundError:
        print(f"Error: The file {file_path} was not found. Please check the file path and try again.")
    except Exception as e:
        print(f"An error occurred: {e}")
```

Example Output of Sentiment Analysis

NEGATIVE COMMENTS

Comment: boring tuts
Sentiment: NEG, Probabilities: {'NEG': 0.9649246335029602, 'NEU': 0.02948511578142643, 'POS': 0.005590261891484260 6}

Comment: @sufyanraza5273 It's not working for me either
Sentiment: NEG, Probabilities: {'NEG': 0.9503383636474609, 'NEU': 0.045963775366544724, 'POS': 0.003697913372889161}

POSITIVE COMMENTS

Comment: Excellent introductory videos. I learned a lot more today than in other videos.
Sentiment: POS, Probabilities: {'NEG': 0.0022849368397146463, 'NEU': 0.0050857230089604855, 'POS': 0.9926292896270752}

Comment: Very nice to know in a light way what Robot Operating Stystems is. I reccomend this video to everyone who has time, a little patiance and most impportant, int erest in learning the subjetc with you are propably about to start working. Nice job ! Congrats !
Sentiment: POS, Probabilities: {'NEG': 0.001213598414324224, 'NEU': 0.0085079129785299 3, 'POS': 0.990278422832489}

NEUTRAL COMMENTS

Comment: for 17:17, is there a rospy equivalent? I tried typing rospy but I'm not getting anything
Sentiment: NEU, Probabilities: {'NEG': 0.10445399582386017, 'NEU': 0.8870159983634949, 'POS': 0.008529962971806526}

Comment: does ros work in windows ?
Sentiment: NEU, Probabilities: {'NEG': 0.012655528262257576, 'NEU': 0.9688198566436768, 'POS': 0.018524570390582085}

file:///Users/reshmarajan/Downloads/Sentiment%20Analysis%20(4).html

Statistical Analysis

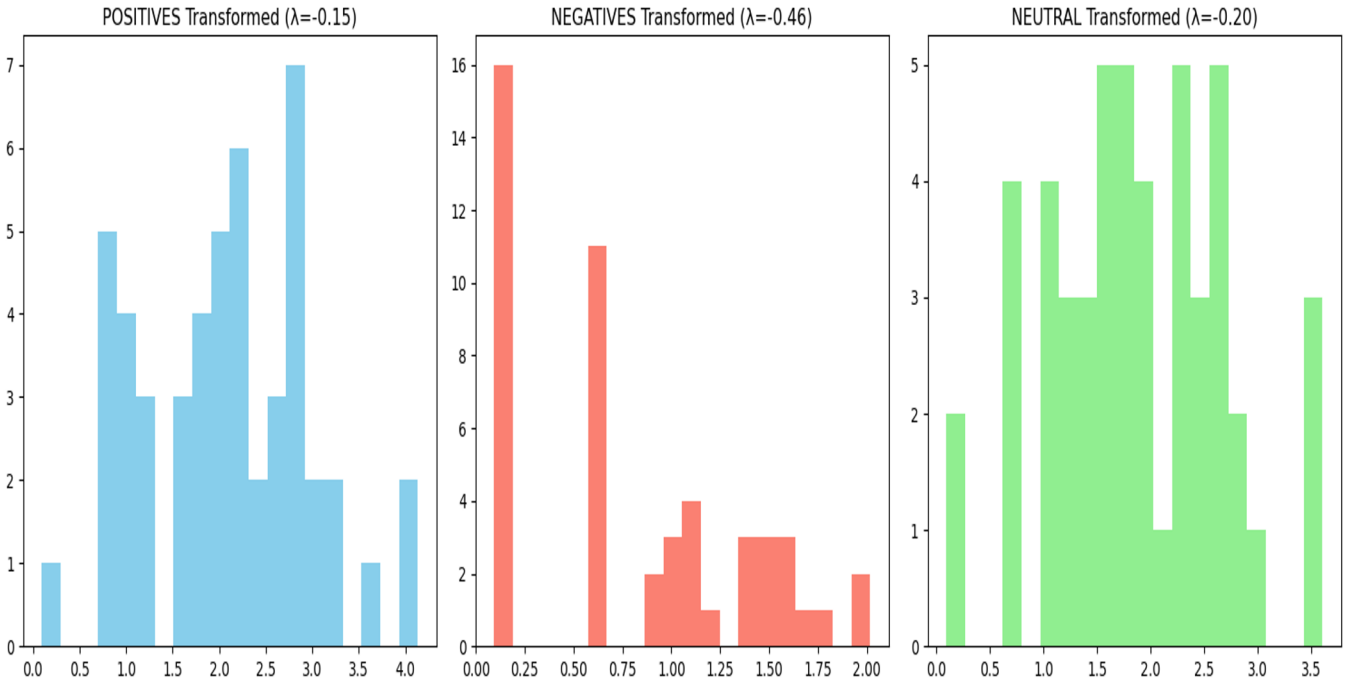
Data Transformation

Box-Cox transformation applied to normalize comment data.

Analysis

Two-way ANOVA test conducted to compare sentiment distributions.

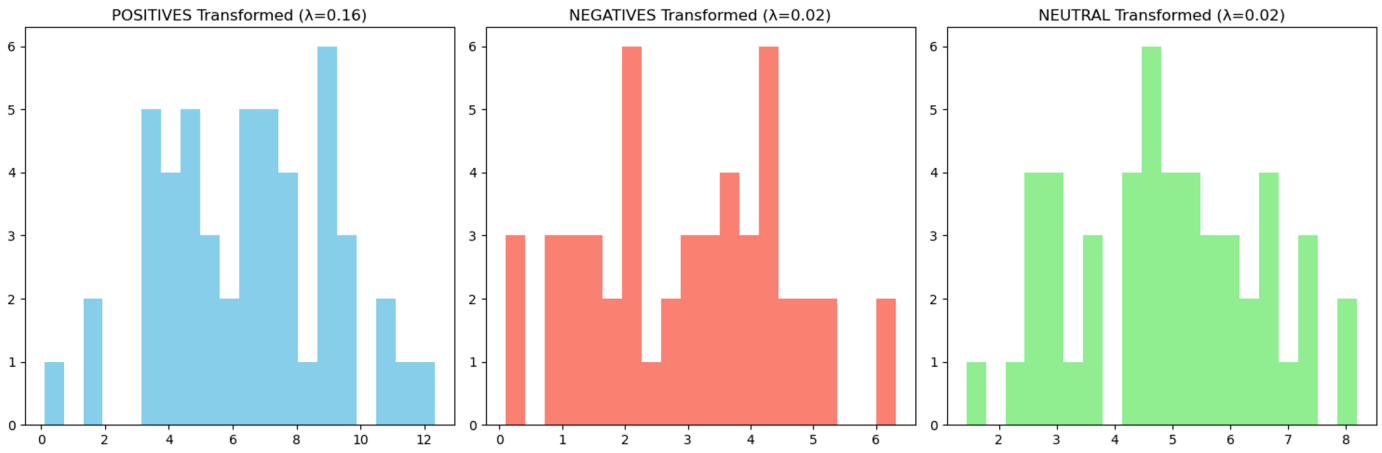
Results- Box Cox Transformation To Normalize Data



CONVENTIONAL VIDEOS

Fig 10. Tranformation of Conventional Robotics Video

Results- Box Cox Transformation To Normalize Data



Embodied Video

Fig 9. Tranformation of Embodied Robotics Video

ANOVA Test

- The objective of this ANOVA analysis was to evaluate the impact of two factors—learning method (hands-on vs. conventional) and comment type (positive, negative, neutral)—on the transformed counts of comments.
- Specifically, the study aimed to determine whether there are significant differences in comment counts based on the learning method, the type of comment, and the interaction between these two factors.

	sum_sq	df	F	PR(>F)
C(Method)	766.276867	1.0	325.116150	1.830210e-49
C(Comment_Count)	292.123585	2.0	61.971136	3.491095e-23
C(Method):C(Comment_Count)	63.280895	2.0	13.424417	2.635658e-06
Residual	692.938197	294.0	NaN	NaN

Results - ANOVA Test

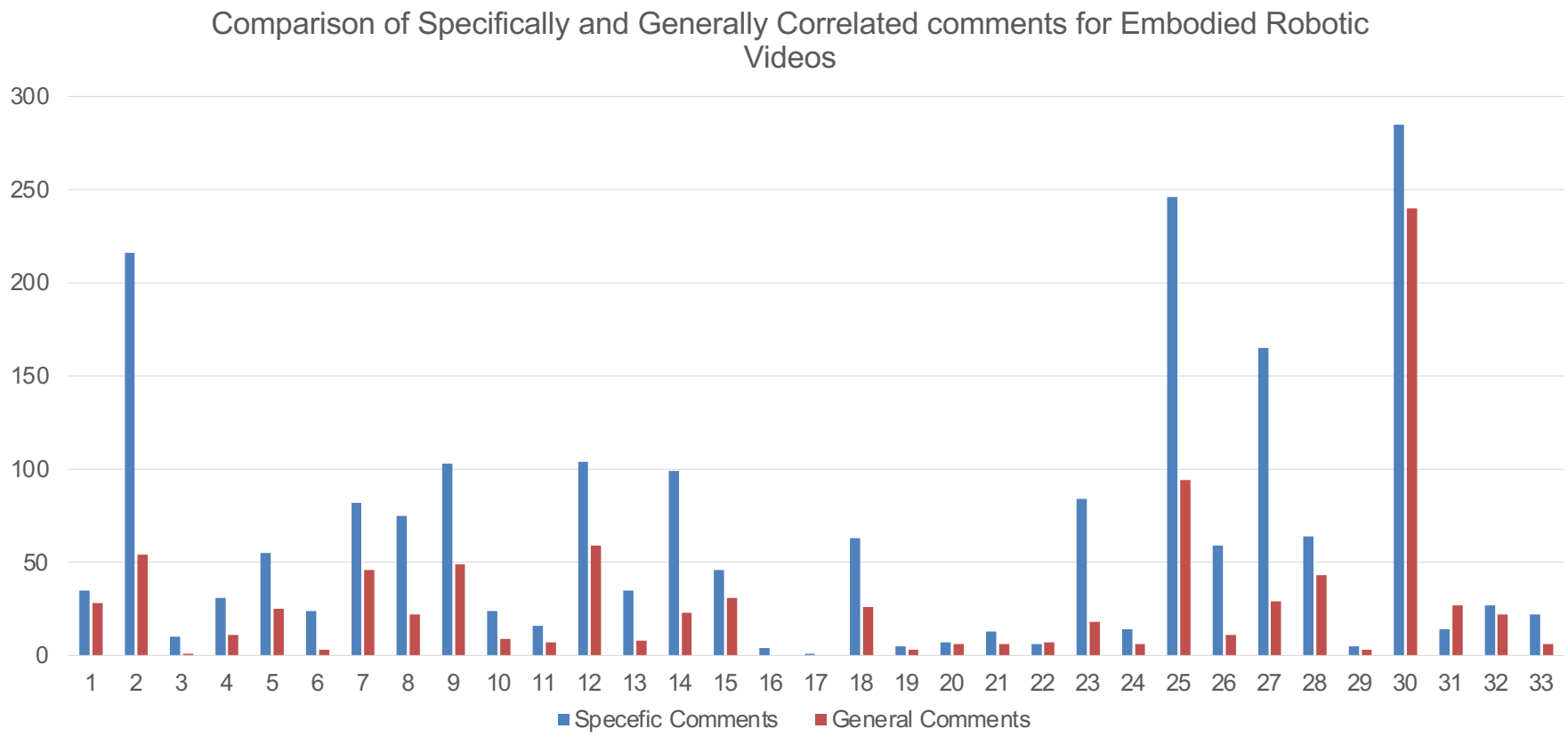
Results

The ANOVA analysis identified the following key results:

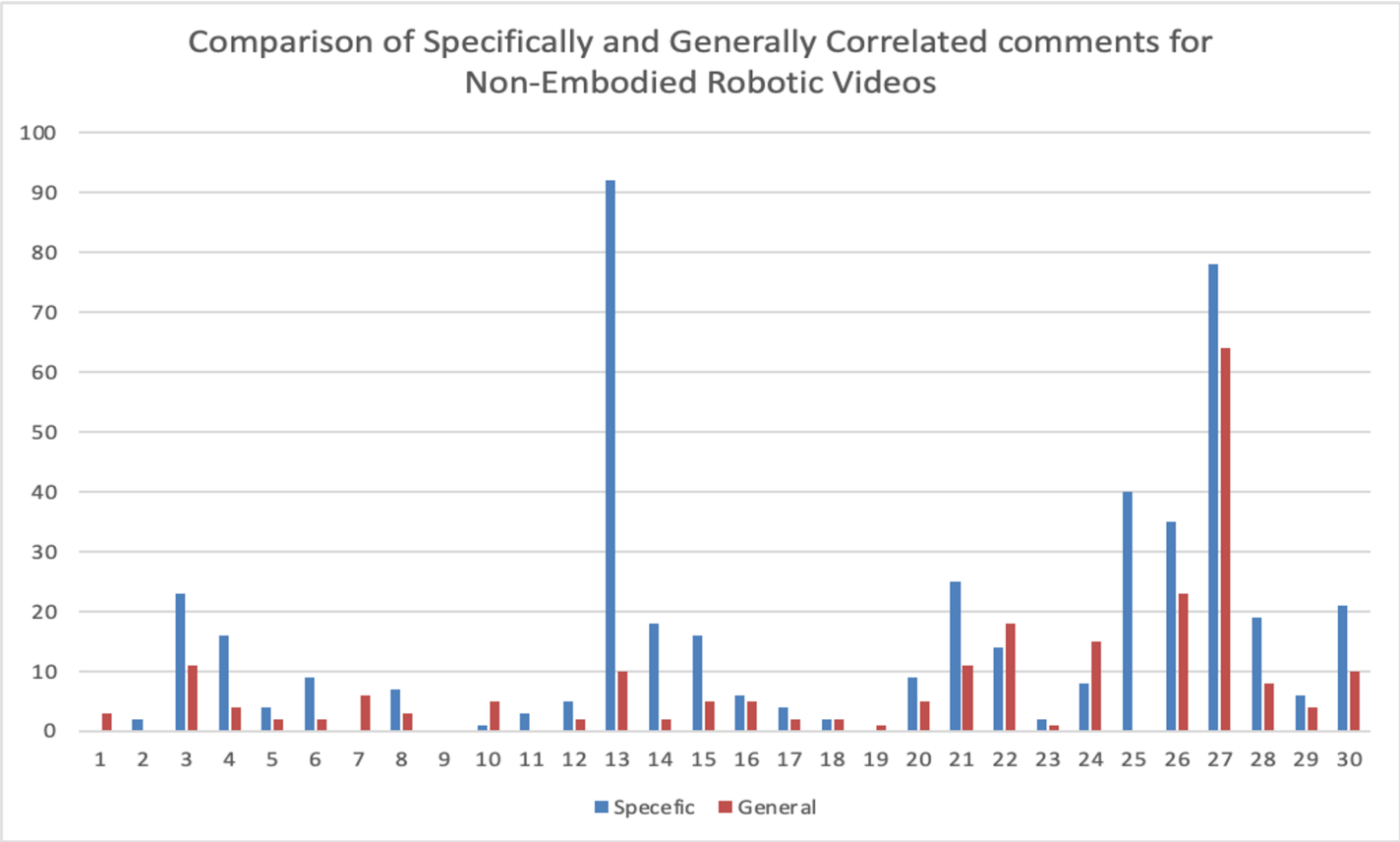
1. **Learning Method**:
    1. The learning method has a highly significant impact on the transformed counts of comments.
    2. Statistical evidence: F-statistic = 325.116150, p-value = 1.830210e-49.
2. **Comment Type**:
    1. The type of comment significantly affects the transformed counts of comments.
    2. Statistical evidence: F-statistic = 61.971136, p-value = 3.491095e-23.
3. **Interaction Effect**:
    1. There is a significant interaction between the learning method and the type of comment.
    2. Statistical evidence: F-statistic = 13.424417, p-value = 2.635658e-06.

- These results suggest that both the learning method and the type of comment independently affect the transformed counts of comments. Additionally, the effect of the learning method on comment counts varies depending on the type of comment, indicating different engagement levels or feedback patterns based on the learning method used.

Specific and Generally Correlated Comments for Embodied Video



Specific and Generally Correlated Comments for Non-Embodied Video



ANOVA Test

	sum_sq	df	F	PR(>F)
C(Type)	178.300122	1.0	22.079404	0.000007
C(Comment_Category)	23.131826	1.0	2.864479	0.093239
C(Type):C(Comment_Category)	0.139252	1.0	0.017244	0.895753
Residual	936.746946	116.0	NaN	NaN

Conclusion:

- The type of video (Conventional vs. Hands-on) has a significant effect on the counts of comments.
- The comment category (Specific vs. General) does not have a significant effect on the counts of comments.
- There is no significant interaction between the type of video and the comment category.

Findings – Correlation Between Transcription and Comments for Embodied Videos

	Number of Correlated Comments	Number of Total Comments
Minimum number	10	160
Maximum Number	280	618
Average Value	101.52	363

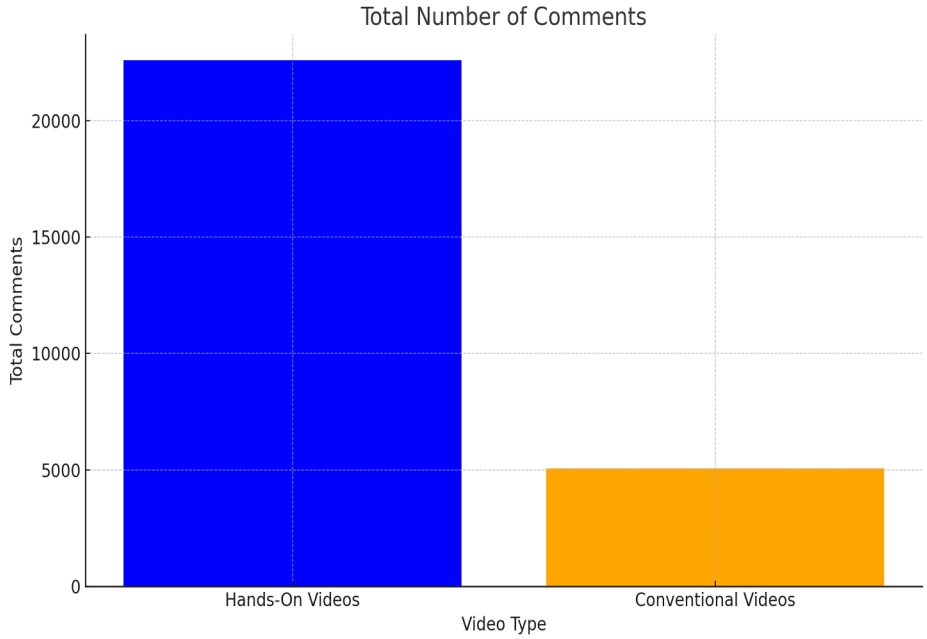
Findings – Correlation Between Transcription and Comments for Conventional Videos

	Number of Correlated Comments per video	Number of Total Comments Per video
Minimum Value	1	1
Maximum Value	34	128
Average Value	4	20

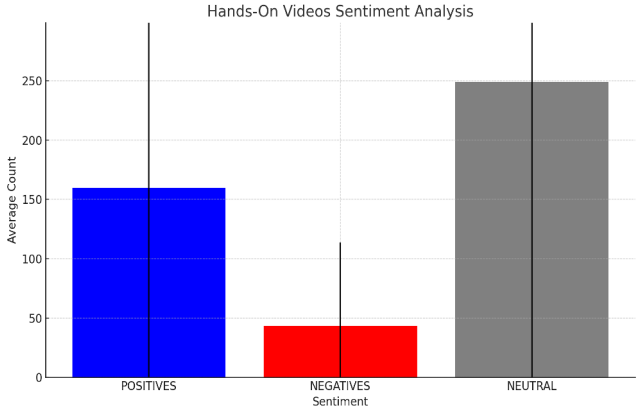
Findings- Comment Distribution

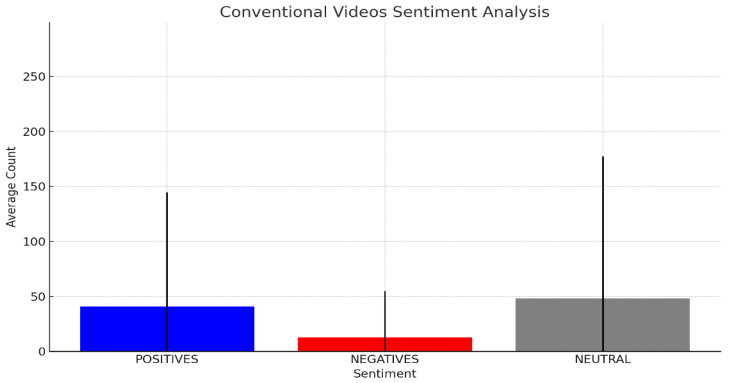
Total Number of Comments

- **Hands-On Videos**: 22,581 comments
- **Conventional Videos**: 5,076 comments
- Hands-On Videos received a significantly higher total number of comments compared to Conventional Videos.



Findings - Sentiment Distribution





	Hands-On Videos (Average)	Conventional Videos (Average)	Difference
Positive Sentiments	159.48	40.78	118.70
Negative Sentiments	43.16	12.62	30.54
Neutral Sentiments	248.98	48.12	200.86

Conclusions of Research

Educational Design: Applying Embodied Learning Principles Effectively in Robotics Education

1. User engagement is higher for embodied learning compared to conventional learning.

2.Users exhibit stronger enthusiasm, resulting in more positive comments.

3.However, there are also some negative comments about embodied learning, indicating room for improvement.

Recommendations: Improve the clarity of embodied learning materials to reduce negative feedback.

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ACKNOWLEDGEMENT

The research is sponsored by National Science Foundation, Division Of Engineering Education and Centers, Award Number: 2306285

Thank You