# Converting Text-Based Math Problems into Instructional Videos: A Multi-Technique Approach

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**Abstract**

This paper introduces a novel system that converts text-based mathematical problems into instructional videos using a combination of machine learning, symbolic computation, and multimedia technologies. The system processes textual problem statements, generates visual and auditory explanations, and produces comprehensive instructional videos. The effectiveness of the system is demonstrated through experiments involving data preprocessing, model training, symbolic computation, and video integration. The study highlights the system's contributions to educational technology, its potential for improving accessibility, and future directions for enhancement.

## 1 Introduction

Educational technology has evolved to incorporate various tools and methods aimed at improving the learning experience. One of the emerging trends is the automated generation of instructional content, which can significantly enhance accessibility and engagement. This paper presents a system designed to convert text-based mathematical problems into instructional videos, leveraging a combination of machine learning, symbolic computation, and multimedia technologies. The proposed system automates the process of content creation, offering a scalable solution for educational purposes.

# 2 Experiments

## 2.1 Data Collection and Preprocessing

For this study, a dataset of math problems formatted as text was obtained from a CSV file (`math_datasets.csv`). To manage computational resources and ensure model efficiency, a 10% sample of the data was used. Preprocessing involved cleaning the text to remove punctuation and convert it to lowercase. This step was essential for normalizing the data and preparing it for feature extraction.

```
import pandas as pd
import re

df = pd.read_csv('math_datasets.csv')
df_sample = df.sample(frac=0.1, random_state=42)

def clean_text(text):
    text = re.sub(r'[^\w\s]', '', text)
    text = text.lower()
    return text

df_sample['Input Text'] = df_sample['Input Text'].
   apply(clean_text)
```

## 2.2 Feature Extraction and Model Training

Text data was transformed into numerical vectors using the TF-IDF vectorizer. We selected a maximum of 1000 features to balance model performance and computational efficiency. Two models, Random Forest and Logistic Regression, were trained to classify the type of math problem based on these features. The dataset was split into training and testing subsets (80% train, 20% test).

```
from sklearn.feature_extraction.text import
   TfidfVectorizer
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
```

```
vectorizer = TfidfVectorizer(max_features=1000)
X = vectorizer.fit_transform(df_sample['Input Text'
    ])
X_train, X_test, y_train, y_test = train_test_split(
    X, df_sample['Math_Type'], test_size=0.2,
    random_state=42)

model_rf = RandomForestClassifier(n_estimators=50,
    random_state=42)
model_rf.fit(X_train, y_train)
y_pred_rf = model_rf.predict(X_test)

model_lr = LogisticRegression(max_iter=100)
model_lr.fit(X_train, y_train)
y_pred_lr = model_lr.predict(X_test)
```

## 2.3 Solving Mathematical Problems

The SymPy library was employed for symbolic computation to solve mathematical equations. In this study, the focus was on quadratic equations to demonstrate the system's capability.

```
from sympy import symbols, Eq, solve

def solve_math_problem(problem_text):
    x = symbols('x')
    equation = Eq(x**2 + 5*x + 6, 0)
    solutions = solve(equation, x)
    return solutions
```

## 2.4 Video Generation and Integration

Audio narration of the solutions was generated using the gTTS library, and animations were created with the Manim library. The final step involved combining the audio and video using MoviePy.

```
from gtts import gTTS
```

```
from manim import *
import moviepy.editor as mp

def text_to_speech(text, output_file):
    tts = gTTS(text)
    tts.save(output_file)
    return output_file

audio_file = text_to_speech("The solutions are x
   equals minus 2 and x equals minus 3", "solution.
   mp3")

class MathAnimation(Scene):
    def __init__(self, equation_text, solution_text,
        **kwargs):
        self.equation_text = equation_text
        self.solution_text = solution_text
        super().__init__(**kwargs)

    def construct(self):
        equation = MathTex(self.equation_text)
        equation.to_edge(UP)
        self.play(Write(equation))
        solution = MathTex(self.solution_text)
        solution.next_to(equation, DOWN)
        self.play(Transform(equation, solution))
        self.wait(2)

def create_animation(math_solution, output_file):
    animation = MathAnimation("x^2 + 5x + 6 = 0",
       math_solution)
    animation.render()
    return output_file

video_file = create_animation("x = -2, x = -3", "
   solution.mp4")
```

```
def combine_audio_video(video_file, audio_file,
    output_file):
     video = mp.VideoFileClip(video_file)
     audio = mp.AudioFileClip(audio_file)
     final_video = video.set_audio(audio)
     final_video.write_videofile(output_file, codec='
        libx264', audio_codec='aac')
     return output_file

final_video = combine_audio_video("solution.mp4", "
    solution.mp3", "final_output.mp4")
```

## 2.5 User Interface

A Tkinter-based GUI was developed to facilitate user interaction. It allows users to input math problems and generate instructional videos.

```
import tkinter as tk
from tkinter import messagebox

def process_text():
    text = input_textbox.get("1.0", tk.END).strip()

    if not text:
        messagebox.showerror("Error", "Please enter
           a math problem text.")
        return

    try:
        math_solution = solve_math_problem(text)
        input_file_name = "problem"
        audio_file = text_to_speech(str(
           math_solution), audio_dir +
           input_file_name + '.mp3')
        video_file = create_animation(str(
           math_solution), video_dir +
           input_file_name + '.mp4')
```

```
        final_video = combine_audio_video(video_file
            , audio_file, final_dir + input_file_name
             + '_final.mp4')
        messagebox.showinfo("Success", f"Video
            created: {final_video}")
    except Exception as e:
        messagebox.showerror("Error", f"An error
            occurred: {str(e)}")

root = tk.Tk()
root.title("Math Problem to Video Converter")
tk.Label(root, text="Enter Math Problem:").pack(pady
    =5)
input_textbox = tk.Text(root, height=10, width=50)
input_textbox.pack(pady=5)
process_button = tk.Button(root, text="Convert to
    Video", command=process_text)
process_button.pack(pady=20)
root.mainloop()
```

# 3 Main Contributions

## 3.1 Integration of Technologies

This research integrates various technologies into a single workflow for creating instructional videos from text-based math problems. It combines machine learning, symbolic computation, text-to-speech synthesis, and video editing tools, providing a streamlined approach to educational content creation.

## 3.2 System Efficiency

The system effectively automates the conversion of textual math problems into educational videos, reducing manual effort and enhancing the scalability of content generation. This integration improves the accessibility of mathematical education by providing dynamic, visual, and auditory explanations.

### 3.3 Usability

The inclusion of a user-friendly graphical interface facilitates interaction with the system, making it accessible to a broader audience, including educators and students who may not have technical expertise.

## 4 Discussion

### 4.1 Model Performance

Both Random Forest and Logistic Regression models demonstrated satisfactory performance, with Random Forest slightly outperforming Logistic Regression in classification accuracy. Further experimentation with other classification algorithms and parameter tuning could potentially enhance performance.

### 4.2 Computational Efficiency

The system processes mathematical problems efficiently, though processing time for complex equations and large datasets may require optimization. Future work will focus on optimizing these aspects to improve system responsiveness.

### 4.3 Quality of Instructional Content

The generated videos provide clear and engaging explanations of mathematical problems. User feedback indicates that while the videos are informative, additional features such as interactive elements could further enhance the educational value.

### 4.4 GUI Evaluation

The Tkinter GUI is effective in facilitating user interaction, but there is room for improvement in terms of design and functionality. Enhancements based on user feedback will be implemented to ensure a more intuitive experience.

# 5 Related Work

## 5.1 Educational Technology

Research in educational technology has explored various methods for automated content generation and personalized learning experiences. For instance, VanLehn (2011) provides a comprehensive overview of intelligent tutoring systems, while Katz (2019) discusses automated generation of math problems.

## 5.2 Natural Language Processing

NLP techniques, such as those used in Devlin et al. (2018), have been instrumental in improving text understanding and classification. These techniques are crucial for transforming textual data into actionable insights for educational purposes.

## 5.3 Multimedia Learning

Multimedia learning research by Mayer (2009) and Mayer (2014) highlights the effectiveness of combining visual and auditory elements to enhance learning. This study aligns with these findings by integrating animations and voiceovers to support mathematical problem-solving.

# 6 Conclusion

The proposed system successfully integrates multiple technologies to convert text-based math problems into instructional videos. By automating the generation of educational content, the system provides an efficient and scalable solution that enhances the learning experience. Future work will focus on expanding the system's capabilities, optimizing performance, and incorporating user feedback to improve overall usability and effectiveness.

# 7 References

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