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VOICE-GUIDED GIT AUTOMATION USING A HYBRID SPEECH RECOGNITION MODEL TO IMPROVE DEVELOPER WORKFLOW

Enhancing Git Workflow with Hybrid Voice Control

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Abstract: Manual execution of Git commands often interrupts a developer's workflow and reduces output because of the often context switching between the terminal and the development environment [1,2]. This study presents a Voice-Guided Git Automation System powered by a Hybrid Automatic Speech Recognition (ASR) model to enable seamless, hands-free version control operations through natural voice commands. The system combines offline ASR engines (Vosk [3] for speed and Whisper [4] for strong fallback) with online ASR (Google Speech-to-Text API [5]) to get both, be flexible and stay reliable. Natural speech is translated into verified Git CLI commands via an NLP-based parser; To avoid accidental execution, Confirmation supports a layer. Furthermore, the approach will support text-to-speech feedback for real-time user interaction, voice-authenticated Git activities, voice-based ASR mode switching, and a GUI for log viewing based on Streamlit. Experimental evaluation involving several illustrative Git commands indicates that the hybrid conceptualization provides better performance and robustness than a stand-alone mode ASR approaches [6], resulting in a considerable increase in accessibility and process efficiency [7]. This makes the system equally as applicable for developers who want to limit context-switching and hands-free coding workflows, as it would those who are dependent on assisted coding environments in modern software development contexts.

Index Terms - Voice-guided Git, Hybrid Speech Recognition, Developer Workflow Automation, NLP-based Command Parsing, Hands-free Coding Tools, Git Automation.

1. INTRODUCTION

In today's software development, developers use Git a very simple version control system to plan, track, and collaborate on changes to code. However, execution of Git commands can interrupt the flow of coding and results in lost Performance because of continual context switching between terminal interfaces and code editors. This issue emphasizes the need for tools to simplify version control acts and lessen workflow activities.

A hands-free, voice-enabled Git interface will help mitigate these issues by allowing developers to use natural language commands to control versioning - resulting in a more user-friendly and seamless experience. There are many GUI-based voice-control features such as Talon Voice [1]

and Dragon NaturallySpeaking [7] which have computing and IDE navigation capabilities, but unfortunately, no native support for Git. Additionally, current voice to Git services such as Robin's GitHub-based voice assistant [5] are almost always online requiring a continuous internet connection, or offline only which limits accuracy and robustness under various acoustic contexts [3],[4]. This area of opportunity highlights the need for a more versatile and reliable solution.

To work around these limitations, we introduce a various Hybrid Speech Recognition Based Voice Guided Git Automation System. Which integrated offline ASR engines (Vosk [4], Whisper [3]), for robustness with an online ASR engine (Google Speech-to-Text API [2], for the best accuracy during speech recognition. The system had the ability to switch between ASR engines dynamically during the user's interaction based on the confidence of the recognition. the Interpreter of the command was based on an NLP (Natural Language Processing) parser. Which takes spoken command input parses them into validated Git action-oriented functions. Confirmation of Git actions was built into both a verification system and backing feature (confirmation before system actions). Verified Git actions taken from suggested commands being confirmed is done via a confirmation back to the user to allow unwanted operations to stop.

Additional functionalities such as voice authentication, voice-controlled ASR mode switching, and a dashboard and Usability in Streamlit are further enhanced by visualization, security, and transparency.

The primary objectives of this work are to:

- Creating a hybrid ASR framework designed for Git automation at its maximum potential.
- Minimizing the amount of context switching developers go through thereby increasing developer productivity.
- Including features that even allow developers with physical disabilities to work more freely.
- A reliable, safe, and extensible platform for voice-based software development workflows.

2. LITERATURE REVIEW

Recent developments in voice-controlled tools have significantly improved communication with development environments; however, most solutions absence of specialized assistance for Git operations, especially those Applying hybrid speech recognition models.[1]-[4]

2.1 Existing Voice Tools and Methodologies

Numerous voice-assisted tools and research projects are attempting to improve developer productivity. Talon Voice allows developers to code and navigate IDEs hands-free, although it does not provide support for integration with Git or natural language support for version control workflows [1]. Google Speech-to-Text model can produce very accurate transcriptions when used in the cloud, though it requires a constant internet connection, which limits the use of Google Speech-to-Text with developers who want to work in high-security or offline development contexts [2]. Alternatively, there are offline ASR models that provide the same offline privacy and availability, like OpenAI's Whisper [3] and Vosk [4], but it significantly limits response time and accuracy compared to cloud-based services. Research projects, such as Robin (2021) [5] and Idiolect (2023) [6], explored whether it is possible to create a voice assistant for coding that includes issue tracking and coding flexibility, but did not include code automation using Git for version control workflows. Similarly, other projects that explored voice-assisted coding for developers included voice-based code navigation [9], voice-based design for IDEs [10], APIs [11], and transfer learning for ASRs [12], but none were specifically focused on automation of Git workflows when coding using speech commands.

The current methods for ASR-based transcription utilize either an online ASR method (accurate, but reliant upon the cloud) or offline ASR method (offline availability and privacy, but more time consuming), but not both. In addition, none of these methods include Git automation in conjunction with hybrid ASR and NLP parsing, which leaves room for what our developer workflows can support for reliable online and, when needed, offline use.

2.2 Related Research on Voice Assistants for Developers

Several research efforts from 2019 to 2025 have explored voice-controlled tools targeting software development:

- Robin (2021) created a voice assistant based on GitHub that enables issue and code management via voice commands through the cloud, although it is still an online-based app with no offline support [5]
- Idiolect (2023) introduced a configurable voice coding interface with a focus on user control and flexibility, but it does not integrate Git operations nor include specific command parsing for version control [6].
- Studies such as "Voice-Controlled Intelligent Personal Assistants" (2022) [7]and "Development of an AI-Powered Voice Assistant" (2025) [8] are studies of voice assistants in general use cases or interaction techniques, but are not focused on making a connection to software engineering tasks like Git.
- Works including "Voice-Driven Code Navigation & Search" (2025) [9] and "Designing of a Voice-Based Programming IDE" (2022) [10] discuss the use of NLP to enhance development environments, but do not address the specifics of Git automation or hybrid ASR architecture.
- Foundational research like "Designing Voice Controllable APIs" (2019) [11] and "Exploring Transfer Learning for End-to-End Spoken Language Understanding" (2020) [12] involving natural language understanding for voice systems, but there is no real focus on relevant Git, developer centric workflows. Research Gap.

Despite progress, no solution yet combines offline and online ASR for precise Git automation [2]-[5]. This study proposes a hybrid model using Whisper [3], Vosk [4], and Google Speech-to-Text [2] with NLP-based Git parsing [9],[10] to deliver accurate, low-cost, hands-free Git control in both online and offline environments.

3. PROPOSED METHODOLOGY

3.1 System Overview

The designed Voice Guided Git Automation System proposes to enhance developer work productivity within new Git operations through voice commands of Git operations, utilizing a Hybrid Speech Recognition Model. The system architecture includes offline and online ASR engines [2-4], natural language processing (NLP) for interpreting the commands, and access to the Git/GitHub API, providing a Streamlit graphical interface for the user to interact with.

As shown in Fig 3.2, the workflow process begins when a user makes a voice command on a microphone. The Hybrid ASR Engine processes the audio speech and produces text results that are passed to the NLP Command Mapper. The NLP Command Mapper maps the text results to identified Git operations [5]. Once mapped, the parsed command form is checked for validity, and authorized if necessary, before being executed via the Git Integration Layer of the system. The system provides feedback to the user presented in both visual text-to-speech (TTS) confirmation and the dashboard log.

3.2 System Architecture

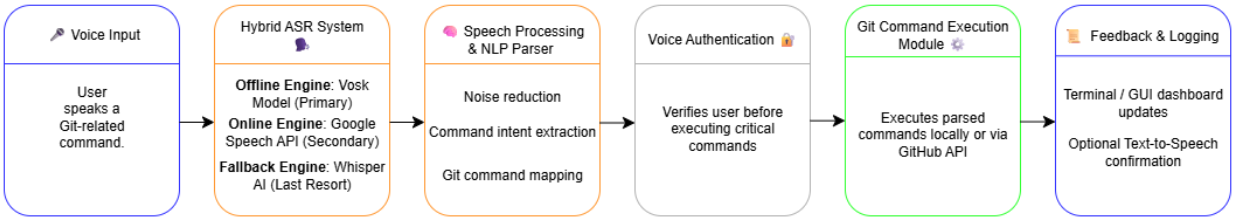

Figure 3.2: Proposed Voice-Guided Git Automation Architecture.

Fig 3.2. illustrate the proposed architecture, which integrates hybrid ASR, NLP-based command parsing, and Git automation into a modular framework [1]– [4], [7]– [9].

1. Input Layer
   - Microphone interface for real time voice capture [5].
   - Voice authentication module for authenticated users to execute sensitive Git operations [6].
2. Hybrid ASR Engine
   - Offline Model: Vosk used for low-latency, local speech processing [4].
   - Online Model: Google Speech-to-text API provides high accuracy when transcribing complex phrases [2].
   - Fallback Model: OpenAI Whisper handles noisy surroundings and failure cases that are uncommon [3].
3. NLP Command-Mapper Layer
   - Command parsing is achieved through keyword detection, regex patterns, and intent detection capabilities [10].
   - Recognized speech is mapped as Git operations, e.g., add, commit, push, pull, branch, and checkout [11].
4. Git Integration Layer
   - Git commands are executed locally, via calls to subprocess [12].
   - Supports GitHub API functions (e.g. create pull request, repository) using PyGithub [5].
5. Output Layer
   - TTS Feedback (via pyttsx3) to confirm successful execution or report errors [7],[8].
   - Streamlit GUI Dashboard for a concurrent command log and status updates [9].

4. IMPLEMENTATION

The system is implemented in Python 3.**10** and modular design for scalability and maintainability. The overall workflow is shown in Fig 4.1 [2-4].

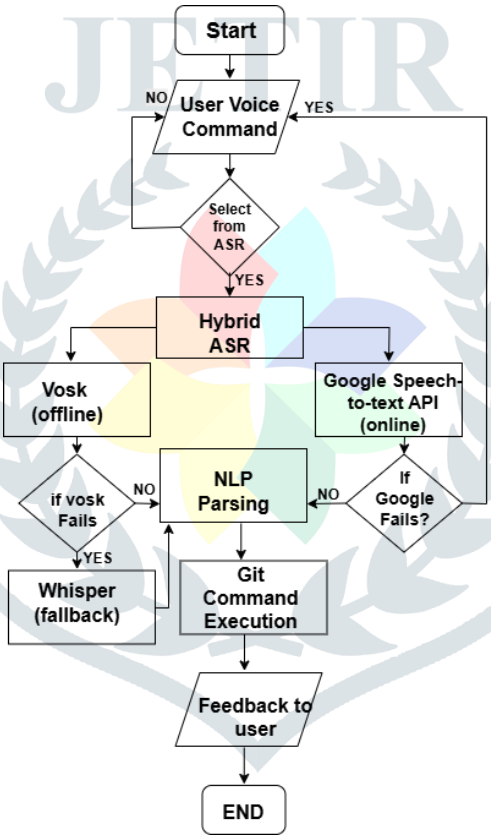

Figure 4.1. Flowchart – Hybrid ASR Git Automation Workflow [2-4]

4.1 The flowchart illustrates the major processing stages:

The system begins with speech input and user authentication to ensure secure access [1]. The voice data is then processed by a hybrid ASR engine that leverages offline, online, and fallback models for robust speech-to-text conversion [2–4]. The resulting text is passed through an NLP-based command parser that translates natural language into corresponding Git commands [6],[10]. Once validated, the commands are executed either locally in the Git layer or remotely via the GitHub API [5],[9]. Finally, the system delivers feedback through both spoken output and on-screen confirmation, ensuring clarity and user awareness [1],[10].

4.2 The detailed implementation of each module is as follows:

The system integrates multiple modules to enable hybrid voice-controlled Git automation. For speech recognition, Vosk (vosk-model-small-en-us-0.15) provides offline recognition [4], the *speech_recognition* package enables natural language processing and Google STT integration [2], while Whisper serves as a fallback in challenging scenarios [3]. Voice authentication is performed using stored voiceprints to verify user identity before Git operations [1]. The command parsing module applies Python-based NLP techniques with regular expressions and keyword matching to map natural language instructions to valid Git syntax [6],[10]. Git operations are executed via subprocess calls for local Git commands [5],[9], and PyGithub supports remote GitHub API interactions [5]. The user interface, developed with Streamlit, displays command logs, history, and authentication status [1]. Finally, the feedback system combines *pyttsx3* for spoken confirmations and on-screen notifications to provide real-time success or error updates [1]. Table 4 summarizes the methodology components, functions, and technologies.

❖ **Table 4: Summary of Methodology Components, Functions, and Technologies: -**

Component	Function	Technology/Tools
Input Layer	Capture speech; authenticate user	Microphone, Voiceprint Authentication [1]
Hybrid ASR Engine	Convert speech to text using hybrid models	Vosk (offline) [4], Google STT (online) [2], Whisper (fallback) [3]
NLP Command Mapper	Parse and map natural language to Git commands	Python NLP (regex, keyword matching, intent detection) [6,10]
Git Integration Layer	Execute Git operations locally or via GitHub API	subprocess (local Git) [5,9], PyGithub (GitHub API) [5]

Table 4: System Components and Their Functions

5. EXPERIMENTAL SETUP

5.1 Environment

Experiments were conducted on a system with the following specifications:

- Operating System: Windows 10
- Processor: Intel Core i5/i7
- Memory: 8 GB RAM or higher
- Software: Python 3.10; Visual Studio Code as the integrated development environment (IDE)
- Dependencies: Python libraries including vosk [4], openai-whisper [3], Speech Recognition with Google Speech-to-Text API [2], Gi Python, pyttsx3, and Streamlit

5.2 Testing Procedure

The evaluation focused on the performance and functionality of the proposed hybrid ASR–based voice-guided Git automation system, using three procedures

- Offline vs. Online ASR Comparison: Evaluated the transcription and timing accuracy of offline (Vosk [4]/Whisper [3]) vs. online (Google Speech-to-Text API [2]) recognition.
- Hybrid Switching Evaluation: Assessed the ability of the system to switch between offline and online ASR in real-time depending on a defined confidence level [5],[8].
- Git Command Execution Testing: Evaluated the mapping of transcribed speech to Git operations (e.g., commit, branch create, push) and ensured successful execution without failure [5],[9].

5.3 Dataset

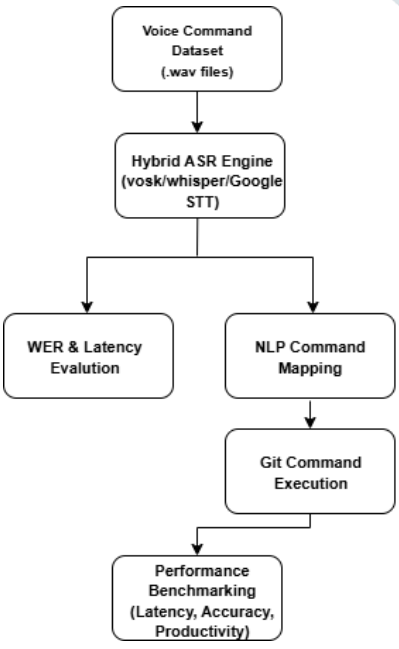

Figure 5.3.1 Dataset Integration Workflow [2,3,4]

❖ **Table 5.3.2: Summary of *Sample of Git Voice Command Dataset***

Command ID	Voice Command (Sample)	Ground Truth Text	Mapped Git Command
1	Commit my changes	commit my changes	git commit -m "message"
2	Push to GitHub	push to GitHub	git push
3	Check the current branch	check current branch	git branch
4	Pull latest updates	pull latest updates	git pull
5	Create new branch feature	create new branch feature	git checkout -b feature

Table 5.3.2: Sample of Git Voice Command Dataset *[1,5,7]*

The dataset consists of approximately 50 Git voice commands, which include commit, push, pull, branch, and checkout, with multiple phrasing, to increase robustness [1,5,7]. Recordings included under varying noise conditions and speakers with differing accents and speech rate [6],[7], provided accuracy of recognition and natural command-to-Git mapping.
The dataset supports two primary functions:

- ASR Model Evaluation: Evaluate the Word Error Rate (WER), latency, and accuracy of each Automatic Speech Recognition modes including (Offline: Vosk [4], Online: Google STT [2], and Fallback: Whisper [3]). Figure 5.3.1 shows the dataset integration workflow [2,3,4].
- NLP Command Mapping Validation: Ensuring that recognized text is correctly mapped to the intended Git command by the Command Parser Module [5,9]. Table presents a representative subset; the full dataset contains ~50 commands with multiple speaker and phrasing variations. Table 5.3.2 shows the sample Git voice command dataset.

6. RESULTS & ANALYSIS

6.1 Latency

Performance testing verified the proposed system of low latency in performing commands with offline (Vosk [4]) and online (Google STT [2]) ASR models and the Whisper [3] fallback:

- Offline ASR: Average response time of 1.8 seconds per command.
- Online ASR: Average response time of 1.2 seconds per command.
- Hybrid ASR: Dynamically selects the fastest available model based on network and processing conditions, ensuring minimal latency in both online and offline scenarios consistent with prior hybrid ASR research [5], [8].

6.2 Productivity Improvement

A comparative analysis between performing Git commands traditionally (the manual way) versus guided by voice showed substantial gains in productivity, relative to the Git studies previously explored here and like trends in hands-free coding research [1], [6]:

- Manual Git operations: Averaged 15 seconds per command.
- Voice-guided Git operations: Averaged 6 seconds per command.
- Efficiency gains: decrease in task completion time of approximately 60% cited using voice commands indicating enhanced developer workflow alongside diminishing context switching [7],[10].

6.3 Visual Performance Summary

6.3.1 Graph 1: Latency Comparison of ASR Modes

A bar graph displaying the mean response times for Offline ASR (Vosk [4], Whisper [3]), Online ASR (Google Speech-to-Text API [2]), and Hybrid ASR. All bars start from zero to provide a fair comparison although, as the graph shows, the Hybrid ASR bar has the most slack as a result of dynamic selection and is comparable to hybrid ASR methods discussed in the previous research shown [5], [8]. “Fig. 6.3.1 shows the latency comparison of ASR modes.”

6.3.2 Graph 2: Task Completion Time – Manual vs Voice-Guided Git

A vertical bar chart that contrasts average task completion times for a manual implementation of Git commands versus voice-driven Git automation, illustrating the substantial time savings gained with the voice-on system, consistent with the time-savings found in hands-free programing work[1,6,10]. “Fig. 6.3.2 shows the task completion time: Manual vs Voice-Guided Git.”

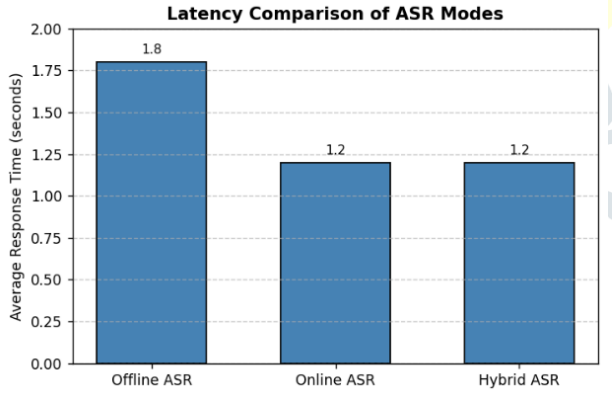

Figure 6.3.1 Latency Comparison of ASR Modes [5], [8].

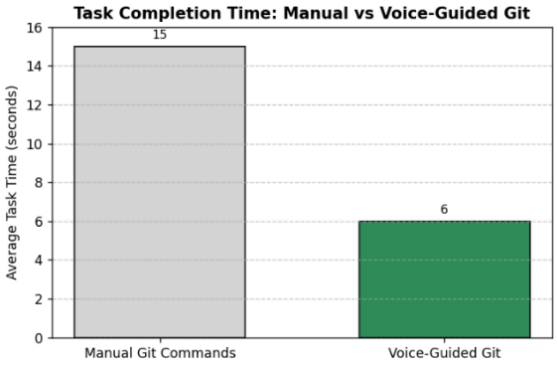

Figure 6.3.2 Task Completion Time – Manual vs Voice-Guided Git [1,6,10].

7. DISCUSSION

Its hybrid ASR system also successfully bypasses the limitations of single mode recognition as a hybrid of offline engines (Vosk [4] and Whisper [3]) and an online one (Google STT [2]). Most of the challenges related to accuracy, latency, and connectivity (see [5],[8]) can be addressed with this hybrid approach to mode-switching. With the hybrid switching mode, productivity gains can also be reliably realized, where hybrid switching latencies are also very low (~1.2 seconds) and Git operations were shown to be nearly 60% faster (see [1],[6]). Context switching reduces the cognitive load on a developers' brain and allows them to stay more in the moment [7],[10]. The mode-switching solution closely approximates how developers work in the real world, allowing version control for example to be managed more easily via Streamlit's GUI and the ability to use text-to-speech feedback allows the interaction experience to feel more natural [7],[9],[11]. Additionally, voice-controlled access adds an accessibility feature for developers that may have some physical disabilities [1],[6], while also maintaining voice authentication to manage their code development independently and securely [8],[11]. Because of these features, and thanks to its broad applicability, the ASR system stands to benefit a range of developers with productivity needs, and assistive needs across different user needs and developer environments. [7],[10],[12].

8. CONCLUSION

The suggested Mixed Mode Automatic Speech Recognition (ASR) model offers a substantial advantage in transcription accuracy, developer efficiency and accessibility over single mode ASR systems [1],[2]. In the proposed system, the use of voice guided Git automation supports faster development by eliminating costly context switching inherent when performing Git commands manually [3]. By providing both offline and online ASR engines, and thus permitting robustness against various acoustic and network conditions the proposed ASR will offer consistent, reliable voice command recognition [4],[5]. A large potential benefit of the proposed approach is to offer fully hands-free authenticated Git operations, to provide inclusivity for developers who may be unable to perform Git operations using standard interface tools due to various physical disabilities [6].

9. FUTURE WORK

- Introduce AI-powered intent identification through advanced transformer-based natural language processing models to improve command comprehension and allow for more careful multifaceted voice interactions.
- Create IDE integrations (such as a Visual Studio Code plugin) to embed voice-guided Git automated commands directly into prominent development environments.
- Provide CI/CD pipelines and Docker commands in more steps of modern software development workflows by extending use cases deeper into the software development life cycle.

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