

“Hey CAI” - Conversational AI Enabled User Interface for HPC Tools

Presentation at the 10th Annual MVAPICH User Group (MUG) Meeting (MUG '22)

Pouya Kousha, Arpan Jain, Ayyappa Kolli, Prasanna Sainath, Saisree Miriyala
Hari Subramoni, Aamir Shafi, and Dhableswar K. Panda



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The Ohio State University

kousha.2@osu.edu

<https://twitter.com/mvapich>

Presentation Outline

- **Introduction and Motivation**
- Problem Statement and Proposed Designs
- Performance Evaluation
- Demo
- Concluding Remarks

HPC Profiling Tools and Broad Challenges

- Analyzing performance bottlenecks for HPC is a complicated but critical task
- New and expert HPC users often have a hard time in understanding the performance of their parallel workloads HPC administrators
 - Learning the tool interfaces
 - Learning tool features and the terminologies
- There is a steep learning curves for utilizing HPC profiling tools!

The challenge is to provide intuitive and simple—yet efficient—interfaces to HPC software and hardware resources to eliminate the steep learning curve of HPC tools

Motivation



Courtesy: Paramount Domestic Television

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Problem Statement

- Are there any **databases for HPC** phrases and terminology?
- Can we use the existing **Automatic Speech Recognition(ASR)** models for converting speech to text?
- Are there any existing **Natural Language Understanding(NLU)** model for HPC tools?
- What are the challenges in **enabling Conversational AI Interface(CAI)** for HPC tools?
- How to **integrate** CAI to existing HPC tools?

Proposed Framework



Text Query

Speech Query

**Automatic Speech
Recognition (ASR)**

Natural Language Understanding (NLU)

Interface between Conversational AI and HPC Tools

Integration of Conversational Interface to HPC Tools

Showing Performance Visualization

Generating HPC Dataset for Speech and Text

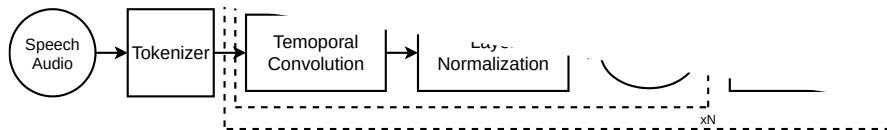
We create an HPC dataset for text and speech containing HPC terminology:

- i. Generated basic queries and labeled their slots and intents
 - ii. Developed synonyms for HPC terminologies
 - iii. Used the synonyms to generate combinations of queries and labeled their slots and intents in human-supervised manner
- The dataset contains four profiling intents:
 - node usage
 - network usage
 - process usage
 - statistics

Training Speech and Text Processing Models for HPC

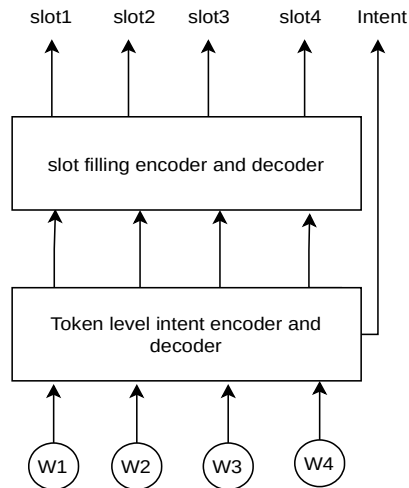
Trained Wav2Vec and Speech2Text models for speech with hyper-parameters tuning on a combination of our in-house HPC-ASR dataset and TIMIT

Wav2Vec
architecture



Natural Language Understanding (NLU)

- Trained two transformer-based models
 - *StackPropagation*
 - *JointBert*
- Used HPC-NLU Dataset to identify the task or request in the sentence



JointBert
architecture

Integration of Conversational AI to HPC Tools

We selected OSU INAM as the HPC profiling tool to integrate CAI

- Having a URL as input that gives the arguments and visualization selection for our tool to process and handle it

The modifications to our HPC tool is as follows:

1. The tool needs to record the voice and send it to CAI Interface
 2. INAM receives and redirect the response URLs to corresponding web pages (No changes)
 3. Web UI generator adjusts the values and scopes based on extracted parameters from URL
 4. Data Access Object generates the query to retrieve the data from the database (No changes)
 5. Pass the data to visualization to plots the visualizations (No changes)
- The changes are minimal if the target HPC tool supports web-UI interface

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Evaluation Platform

Deep Learning Framework: PyTorch is used to define and train DNNs for ASR and NLU

Deep Neural Networks: Speech2Text, Wav2Vec, JointBert, and StackPropagation

Datasets: LibriSpeech and TIMIT, HPC-ASR Dataset, HPC-NLU Dataset

Architecture	Type	Cores	Speed (GHz)	Label
Broadwell (Server)	CPU	28	2.4	BDW
SkyLake (Server)	CPU	28	2.6	SKX
K80 (Server)	GPU	4992 (Dual socket)	-	K80
V100 (Server)	GPU	CUDA: 5120 Tensor: 640	-	V100
Intel Core i5 8th gen (Surface Pro)	CPU	4	1.8	Client-1
Intel Core i7 11th gen (HP Pavillion)	CPU	4	2.8	Client-2
Intel Core i5 (MacBook Pro)	CPU	4	1.4	Client-3

ASR+NLU and End-to-end Performance Evaluation

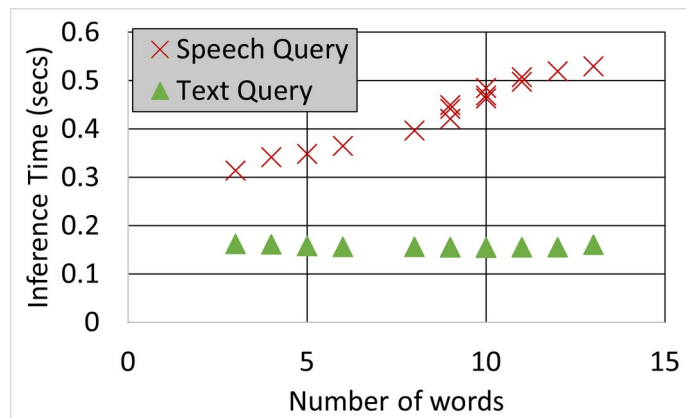
ASR+NLU: ASR and NLU modules are evaluated together as a pipeline to see accuracy of converting speech to intents/slots

- Using JointBert as NLU model

ASR Model	F1 Score for slots	Intent Accuracy
Speech2Text	0.8295	92.92%
Wav2Vec	0.8349	92.47%

End-to-end Overhead: we evaluate Inference latency evaluation from user speech/text input to generating URL and passing it to the tool

- Since different visualizations vary in rendering time they are not included in the latency
- The inference latency of processing speech increases with an increase in the number of words in the query
- The inference latency of processing text remains the same



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Using CAI - Demo

The screenshot shows a web browser window with the address bar set to 'localhost'. The page title is 'OSU INAM'. The interface is divided into two main sections: 'OSU INAM TEXT ASSISTANT' and 'OSU INAM VOICE ASSISTANT'. The text assistant section features a 'Query' input field, a right arrow button, and two buttons labeled 'Inference steps' and 'Visualize'. The voice assistant section has a 'Record' button with a right arrow icon. The footer contains contact information for Dhabaleswar K. (DK) Panda and the address of 774 Dreese Laboratories.

OSU INAM

OSU INAM TEXT ASSISTANT

Query

Inference steps Visualize

OSU INAM VOICE ASSISTANT

Record

Contact: Dhabaleswar K. (DK) Panda
Dept of Computer Science and Engineering
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774 Dreese Laboratories
2015 Neil Avenue
Columbus, OH 43210

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Concluding Remarks

- We explored the challenges for designing a conversational (speech/text) interface for HPC tools and
 - Used state-of-the-art AI models for speech and text and adapted it for use in the HPC by retraining them on new HPC datasets we created
 - Demonstrated that CAI delivers higher accuracy
 - Created an interface to convert speech/text data to commands for OSU INAM
 - Showed how users can utilize the proposed interface to gain insights quicker leading to better productivity
- As future work we plan on releasing various components developed
 - HPC-ASR and HPC-NLU datasets
 - The retrained ASR and NLU models
 - CAI and the enhanced OSU INAM profiling tool with support for CAI
 - Extend CAI to other popular profiling tools
 - Preform user survey

Ref. for more details: Hey CAI- Conversational AI Enabled User Interface for HPC Tools; P. Kousha, A. Jain, A. Kolli, S. Prasanna, S. Miriyala, H. Subramoni, A. Shafi, and DK Panda; ISC'22

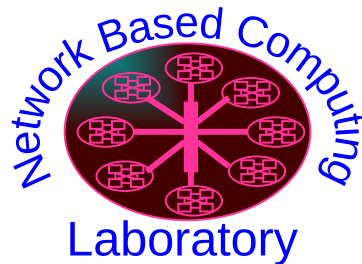


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Thank You!

kousha.2@osu.edu



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