Android Application for Language ID*

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Outline

- Motivation
- Automatic Language Identification (LID)
- SmartPhone Implementation
- System Performance
- Conclusions and Future Work
- Demo

Motivation

- **Any unplanned interaction with someone who does not speak our language requires an interpreter**
- **Language identification is needed first**
- **Recent example in San Diego Harbor (March 27, 2011)**
  - **26-foot sailboat capsized**
  - **First responders did not recognize language**

"…investigators had to bring in interpreters to speak to them, San Diego Fire-Rescue spokesman Maurice Luque said. He did not know what language they spoke."

Applications

- Language-based data filtering
- Pre-processing for automated speech applications such as machine translation and speech recognition
- Requesting human interpreters for emergency situations
- Our focus is to develop a Smartphone application that addresses the latter scenario (i.e. routing language service requests in emergency situations)

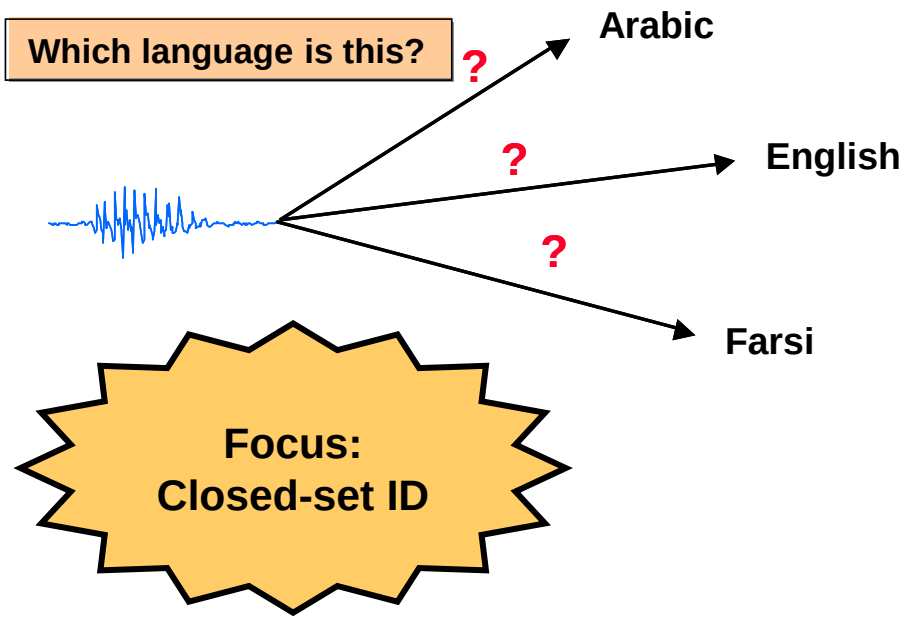
Project Goals

- Implement a LID system on an Android based Smartphone
- Evaluate tradeoffs between computational complexity and performance across several phones
- Evaluate performance of in-phone LID system with field testing
- Develop a prototype application that integrates existing Smartphone capabilities with LID to quickly and efficiently route language service requests

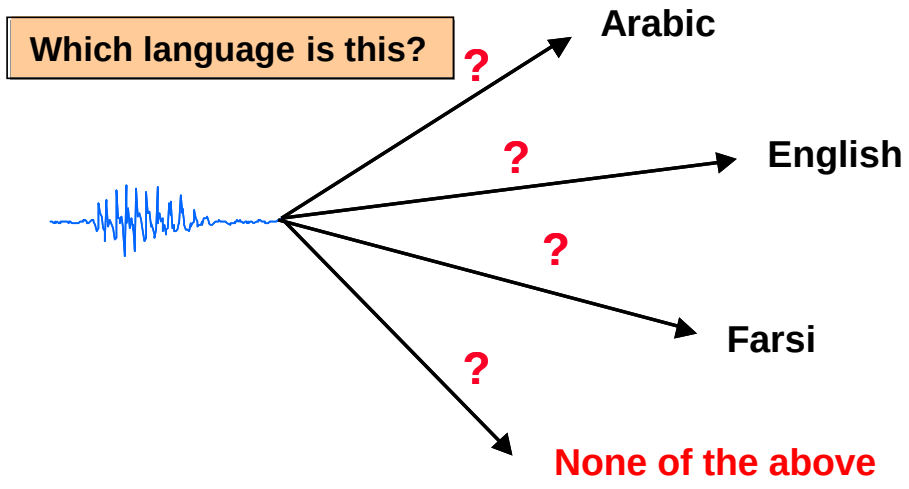
Automatic Language Identification (LID)

- **Automatic language identification is the process of determining the language being spoken in a speech utterance without human intervention**

- **Closed-set identification**
  - **Prior knowledge of all classes**

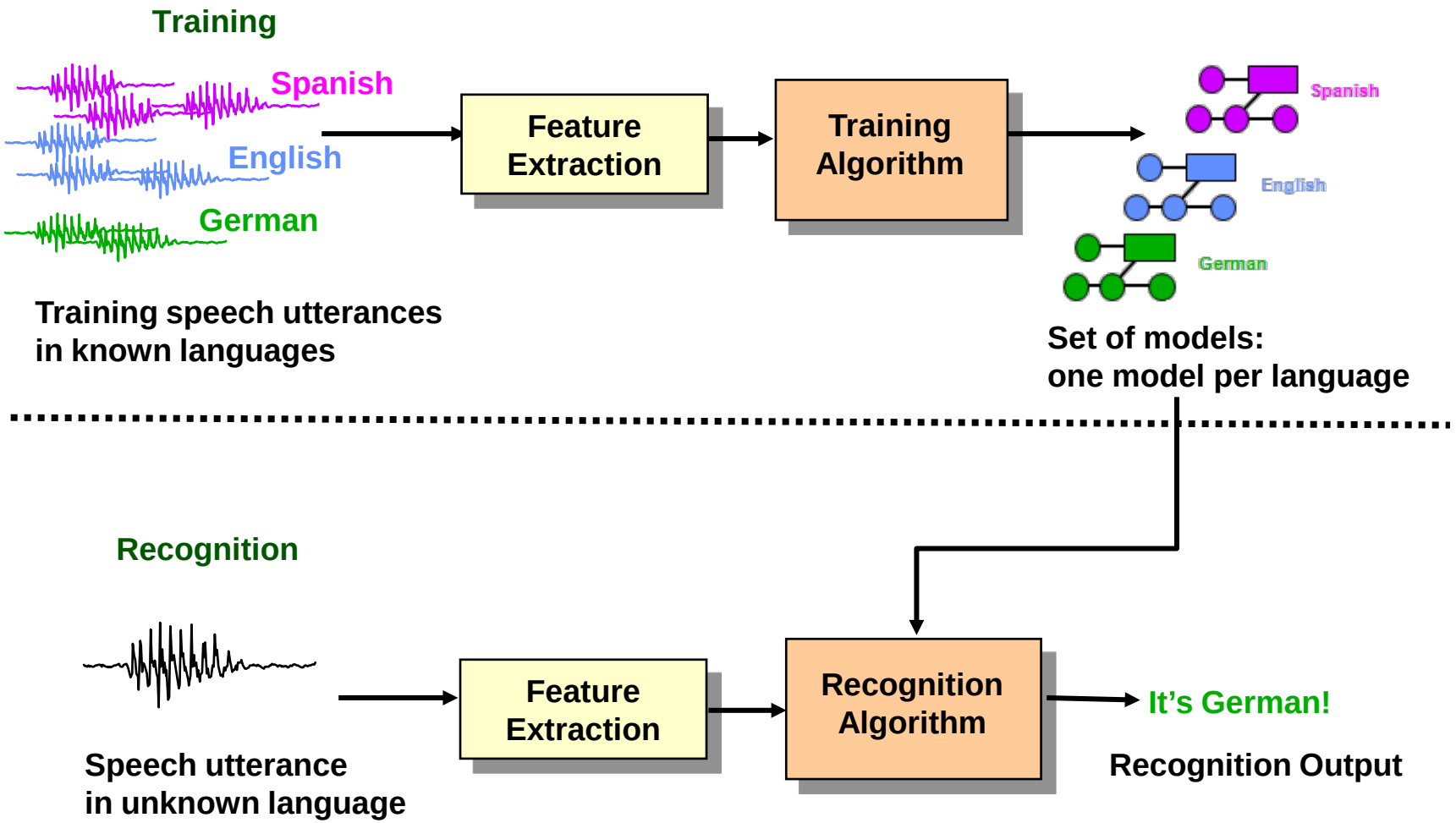


- **Open set identification**
  - **Out of set class**

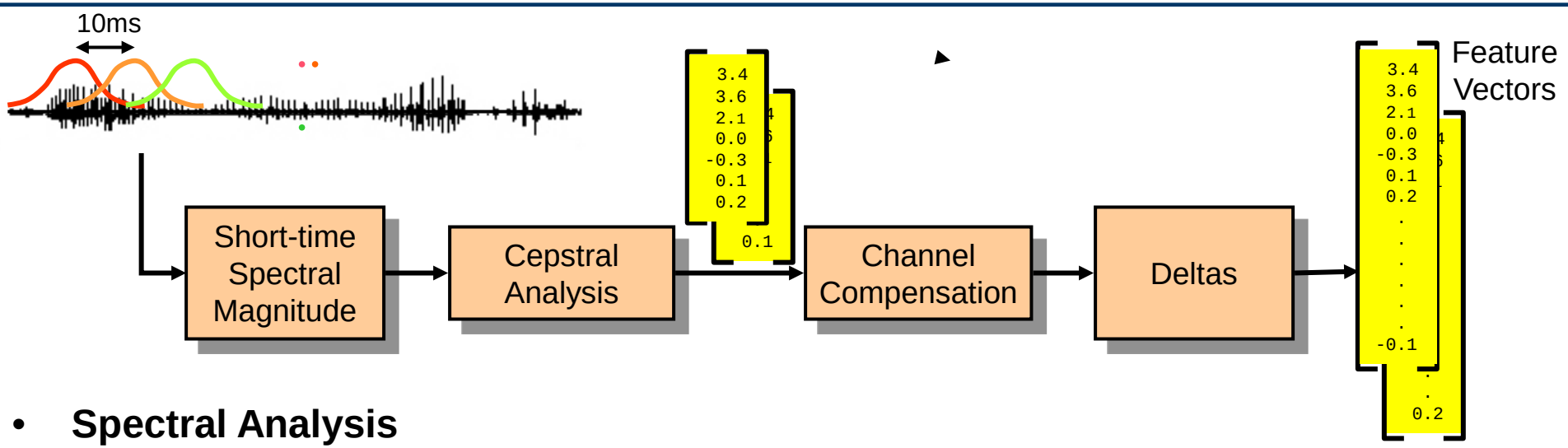


LID System
Architecture

- Language identification task: Find messages spoken in a target language



LID System
Feature Processing



- **Spectral Analysis**

  Generate frequency component information through Short-Time Fourier Transform

- **Cepstral Analysis**

  Separates frequency information that is characteristic of a language from what is common across all languages considered (7 features)

- **Channel Compensation**

  Reduces the effects of differences across channels (landline vs cell phone)

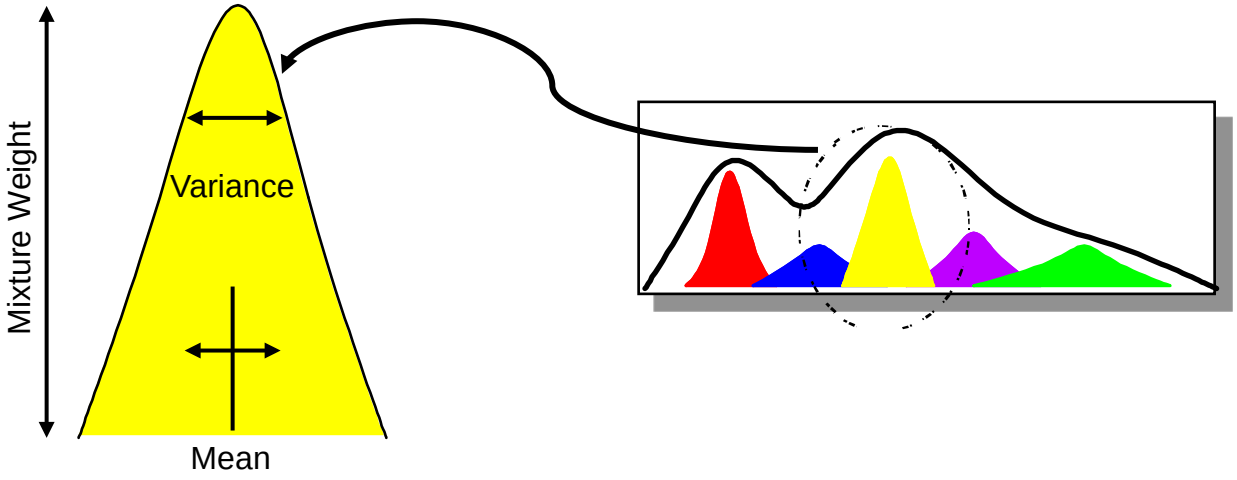
- **Deltas**

  Encode temporal variation of Cepstral features by computing the differences among neighboring frames

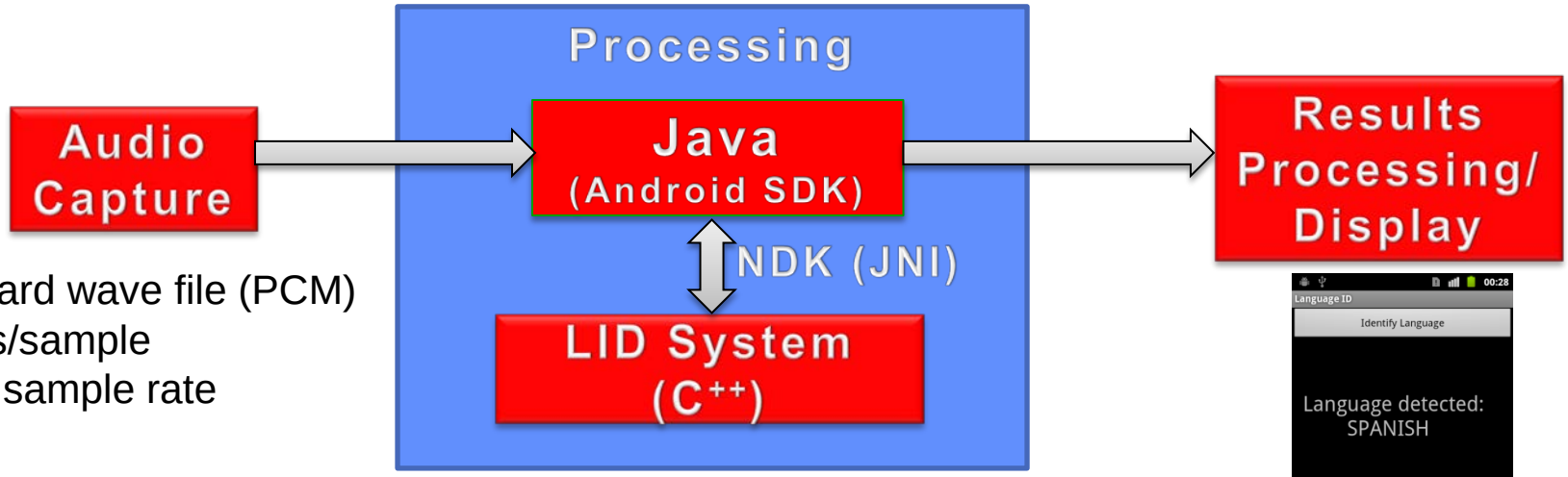
LID System

Gaussian Mixture Modeling

- **Gaussian Mixture Model (GMM)**
  - **Almost any continuous probability distribution can be approximated by a linear combination of Gaussians**
- **Each language is modeled as a probability distribution over the feature variables**



Android LID System Architecture

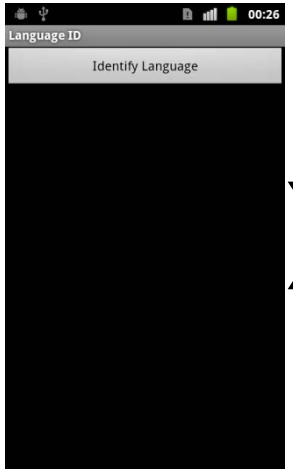


- Standard wave file (PCM)
- 16 bits/sample
- 8kHz sample rate

- As the user speaks, streaming audio is sent to the LID component for processing
- The LID system consists of previously developed technology by the HLT group at Lincoln Laboratory (C++)
- Android's Native Development Kit (NDK) allow us to make use of C++ native code

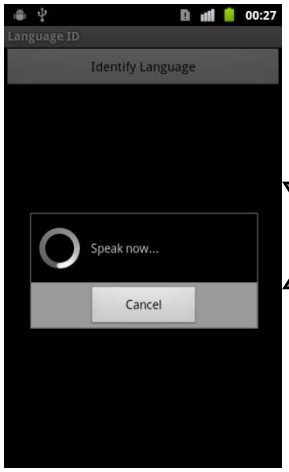
Android Screenshots/Demo

Main screen



User presses button

User speaks for up to 30s



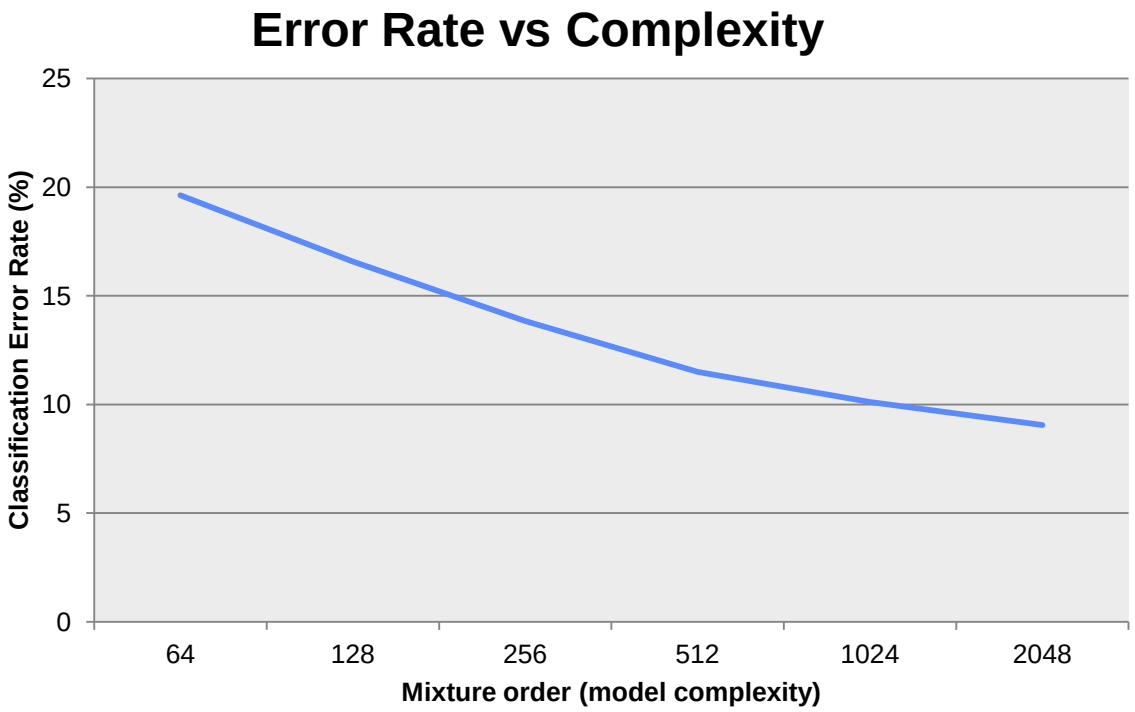
When enough speech captured

Detected language is displayed

- **App starts capturing user's speech and does not stop until final decision is displayed**
- **When a minimum of audio is captured, it is processed**
  - **Minimum audio is a system parameter; currently 7-seconds**
- **A score is generated for each language**
- **If language score > preset threshold**
  - **Decision is displayed, otherwise**
  - **Score all audio captured until this point**

System performance versus model complexity

Computer Simulation



- **Five-Language task: Arabic, Cantonese, English, Mandarin, Spanish**
- **Test sample nominal length: 30s**
- **Task: closed-set ID**

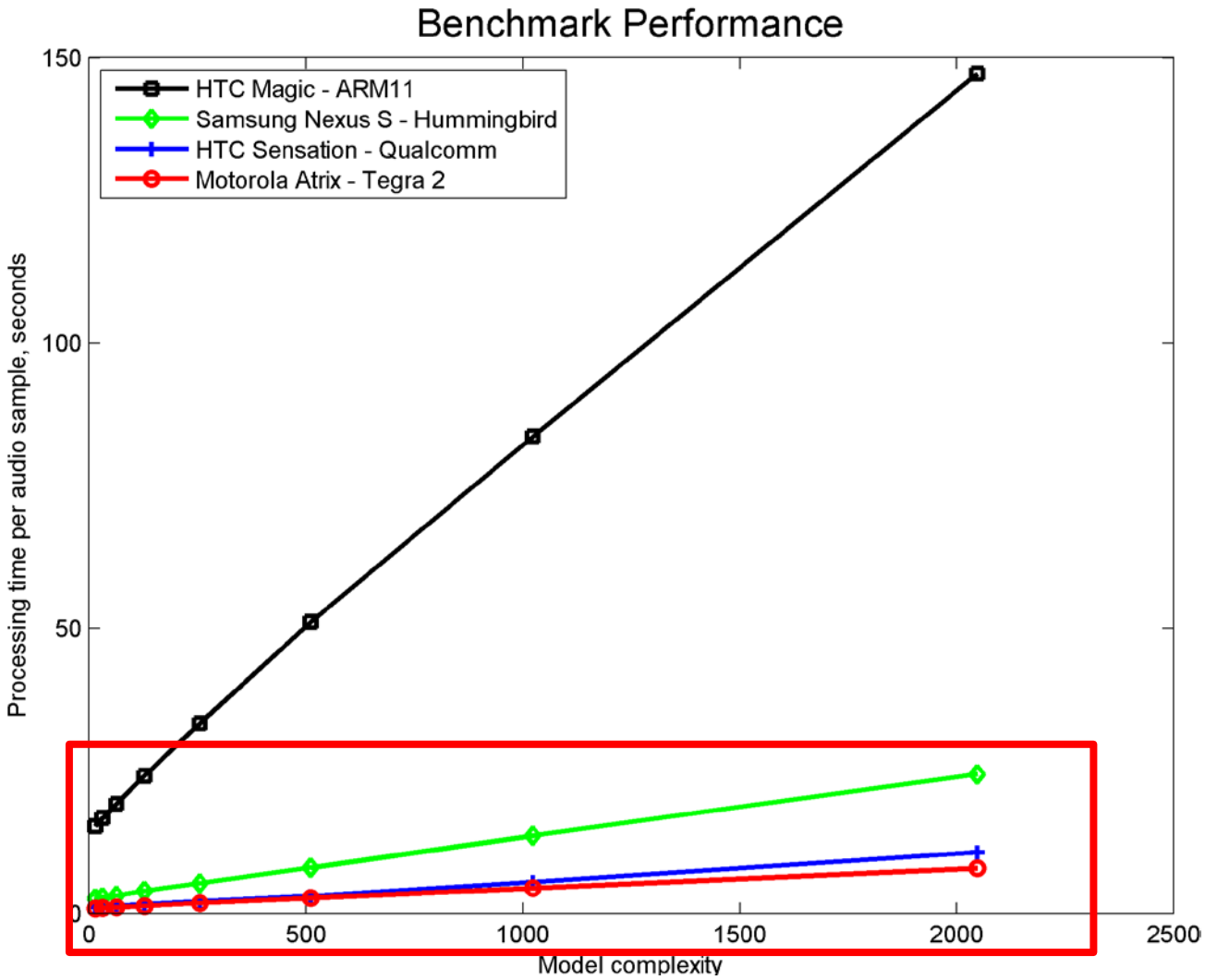
SmartPhone configurations

- **Multiple phones were evaluated**
  - **Older platform (HTC Magic)**
  - **Newer (Atrix)**

	HTC Magic	Samsung Nexus S	HTC Sensation	LG G2x, Motorola Atrix
CPU	Qualcomm MSM7200A	Hummingbird	Qualcomm MSM 8x60	Tegra 2
Processor design	ARM 11	Cortex A8	Scorpion	Cortex A9
Clock	528 MHz	1 GHz	1.2 GHz	1 GHz
Process	90 nm	45 nm	45 nm	40 nm
Out of Order Execution	no	no	partial	yes
Year introduced	2009	2011	2011	2011
Relative performance	1	6	16	18

Average execution time versus model order

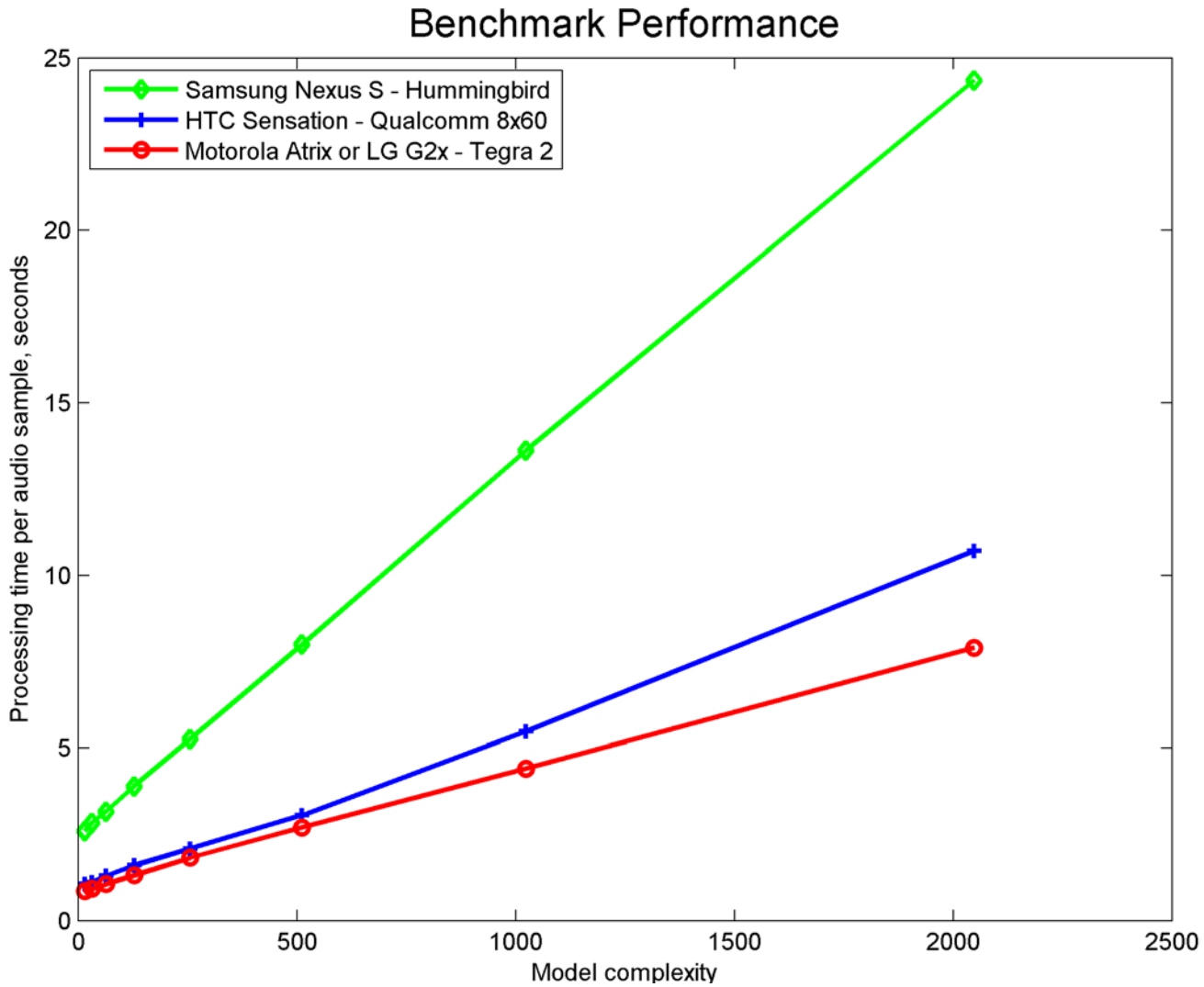
In-SmartPhone Evaluation



- **Task: 5-language closed-set Id**
- **Test sample average duration: 30s**
- **Averaged over 4 test samples**

Average execution time versus model order

In-SmartPhone Evaluation



- **Task: 5-language closed-set Id**
- **Test sample average duration: 30s**
- **Averaged over 4 test samples**

Average execution time for different tasks

In-SmartPhone Evaluation

- **Comparison in execution time between 5 and 50-language task**
- **Fixed model complexity 2048**
- **30-sec samples**
- **Small overhead in computation since in both cases the language independent model is scored and takes most of the processing time**

Phone	5 Languages	50 Languages
Nexus S (Hummingbird)	16.9s	21s
Motorola Atrix	7.9s	9s
HTC	10.7s	11s
Droid X2	5.2s	8.6s
LGE G2X	7.9s	9s

System performance

- **Benchmark Classification Error Rate: 9.1%**
  - **Computer LID system**
  - **Development Set**

- **In-phone evaluation**
  - **Classification Error Rate: ~20%**
  - **7 languages**
    Arabic, Mandarin, Vietnamese, Hindi, Russian, Spanish, Turkish
  - **Half of captured segments < 10s**

- **Potential issue with mismatch between 30s system training and amount of speech provided by users**

System performance

Impact of test segment duration

- **Matched system**
  - **Train and test samples of same duration**

Speech (s)	Classification error rate (%)
6	28.1
12	16.8
18	10.2
24	9.4
30	9.2
Full sample	9.1

- **Mismatched system**
  - **Trained on full sample length**

Speech (s)	Classification error rate (%)
6	29.8
12	17.6
18	12.6
24	10.3
30	9.3
Full sample	9.1

Conclusions and Summary

- State of the art LID technology has been implemented in Android platform
- Successful evaluation conducted over multiple handsets
  - Newer handset perform in real time
- Additional data is needed to support more in-phone testing

Future Work

- Implementation of robustness techniques to enhance mismatch between training data and telephone
- Can performance be improved by using multiple systems in combination?
- Is current speech activity detection aggressive enough?
- Use speech time instead of audio time
- Compensate for shorter durations
  - Likely main current source of mismatch
- Evaluate power consumption/battery life for field use
- Study the open-set problem
- Leverage current implementation to extend to speaker identification