Natural Language Understanding on Low-End Embedded Platforms

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An NLU (Natural Language Understanding) engine is the “brain” of an interactive voice response system.

**Interactive Voice System:**

**Key Components**

- **ASR Engine** (Automatic Speech Recognition) - **EAR**
- **NLU Engine** (Natural Language Understanding) - **BRAIN**
- **TTS Engine** (Text To Speech) - **MOUTH**

### ASR Engine
Audio Transcription

### NLU Engine
Semantic Interpretation

### TTS Engine
Audio
The voice-to-text output of a speech recognition (ASR) engine is semantically meaningless

**Fitness Wearable**

- How was my workout?
- How much did I burn?
- Number of calories, bro?
- My stats for today?
- Did I lose weight?
- Workout summary!

**Home Thermostat**

- It is too cold!
- Can you make it warmer!
- Increase temp by 2, OK?
- Warmer by 2 degrees.
- Need higher temperature.
- Man, I am freezing!
An app developer has to utilize a parser to semantically interpret ASR output for desired application.

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Manually written, rules-based parsers are rigid in their approach, slow to develop, and cumbersome to maintain.

- Specialized Skills
- Slow Development
- High Costs
- Rigid Approach
- Difficult Modification
- Slow Upgrade
Automated, data-trained NLU engines are flexible in their approach, faster to develop, and easier to maintain

- Ordinary Skills
- Fast Development
- Low Costs
- Flexible Approach
- Easy Modification
- Fast Upgrade
New Machine Learning implementations for embedded dramatically reduce data, computation, training, and footprint requirements.
For most “command and control” apps, powerful NLUs can be developed that require less than 100 KB of memory and no OS.

- < 100 KB of RAM + ROM
- Bare Metal Chip (No OS)
- >1,000x Generalization
- Multi-Concept Extraction
- Contextual Interpretation
- All Domains & Languages
Powerful NLUs can be deployed on ordinary embedded platforms without need for OS, FPU, or DSP instructions.

**Low-End Processors**

Cortex®-M processors

- Smallest footprint / lowest power

**High-End Processors**

Cortex®-A processors

- Rich OS
- Highest performance
For sophisticated interaction with a thermostat, NLU can be built with 50 training sentences and requires less than 20 KB of memory.

**ASR Engine**

- 4 Functions: Action, Value, Time, Day
- 6-Slot FSG Template Grammar
- 55 Keywords; 34 Garbage Words
- 100,000+ Utterances

**NLU Engine**

- 50 Tagged Training Sentences
- 100% Accuracy; 2,000x Generalization
- 10 KB Core Library; 4 KB NLU Model
- 5 KB RAM (Core Library + Model)
An embedded NLU can be utilized in an embedded or a distributed implementation for an interactive voice response system.
A variety of major industrial verticals can benefit from embedded Natural Language Understanding systems.
THANK YOU

QUESTIONS?
COMMENTS?
CONCERNS?