Zephyr™ Project
Developer Summit
June 8-10, 2021 • @ZephyrIoT

TensorFlow, Meet Zephyr

Machine Learning with TensorFlow Lite Micro on Zephyr

Outline

- Background
  - Machine Learning and Internet of Things
  - TensorFlow, TensorFlow Lite and TensorFlow Lite for Microcontrollers
  - TensorFlow Lite Micro as a Zephyr module
- Walkthrough and Demonstration
- Conclusion
  - Tips for Developers
  - ~~Plea~~ Tips for Contributors
  - Feedback

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on GitHub and Zephyr Slack

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You? :-0

Have you used TensorFlow?
Better yet, have you used it with Zephyr?

Me :-)

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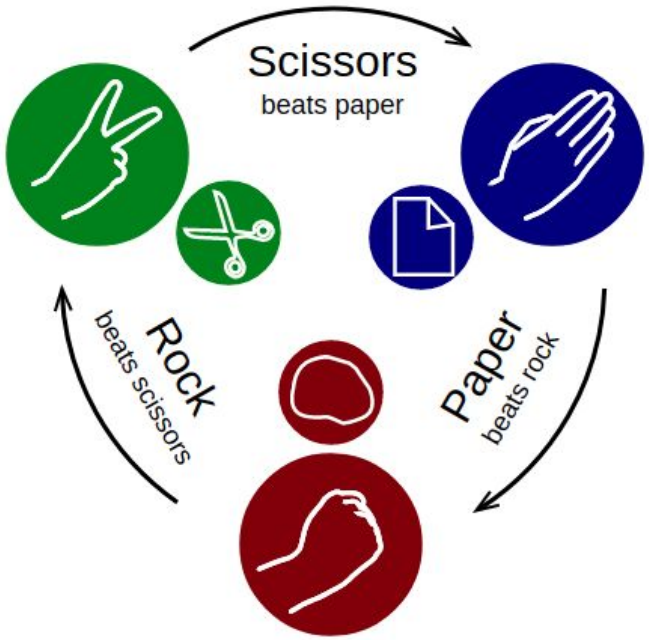
Background

Machine Learning

- Machine learning is (of course) different than programming
- Example: Rock-paper-scissors



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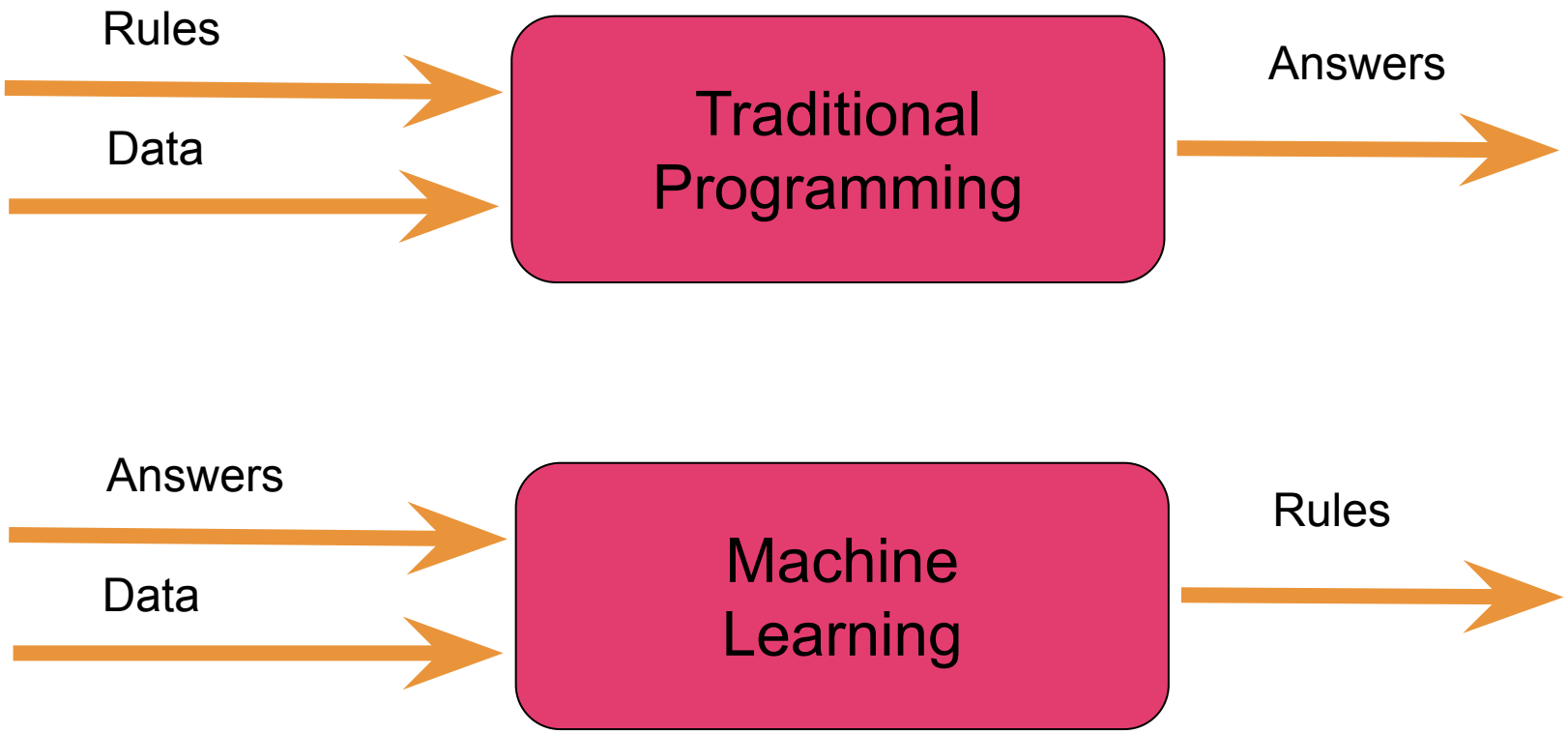
Machine Learning



Machine Learning with TensorFlow

- TensorFlow
  - OSS software stack maintained by Google and hosted on GitHub
  - Written in Python and C++
  - Also an E2E platform and ecosystem
- TensorFlow Lite
  - Software stack for mobile / embedded devices without significant resource constraints
- APIs in several languages
  - Python, C/C++, Java, JS, Go, etc.
- Many companies have adopted TensorFlow and TensorFlow Lite
  - Twitter and Spotify recommendations
  - Google products
  - Intel and ARM have invested in optimizing them on their CPUs and GPUs
- TensorFlow is also used in research

Machine Learning with… a Microcontroller?

- TensorFlow Lite Micro
  - OSS stack written in C/C++ with C++ API
  - For resource-constrained devices
- “But- but- machine learning is for the cloud!”
- Machine learning on the edge has some advantages
  - Less power and data flow due to less network use and more edge computation
  - Already proven in use in the adoption of TensorFlow Lite and TensorFlow for JS
  - As for TensorFlow Lite Micro...
- Example: Satellite

Machine Learning with… a Microcontroller?

- Limitations
  - Support for limited set of platforms
    - Arduino, Cortex M, etc.
  - Support for **limited subset of TensorFlow operations**
  - Low-level C++ API requiring manual memory management
  - **No on-device training**
- You could port TensorFlow Lite Micro to new platforms yourself
  - The library is arithmetic with very few dependencies or requirements
  - You don’t need OS support
- Of course, you could also use...

TensorFlow Lite Micro... on Zephyr!

- Zephyr RTOS has several advantages over bare metal
  - Support for 170+ devices
  - Documentation and tooling
  - Community support and participation
  - Industry and vendor collaboration
- We can provide the support TensorFlow Lite Micro needs…
  - Debug logging
  - C Math library
  - C++ 11 compiler compatibility
  - Global variable initialization
- ...As well as other features you might need, like power management, logging, Bluetooth, and more.
- All you have to do is provide the application!

TensorFlow Lite Micro as a Zephyr Module

- Module support is in as of 2.6!
- People have been able to use TensorFlow Lite Micro on Zephyr before now
  - TensorFlow Lite Micro samples available on litex_vexriscv board
  - **AntMicro demonstration with Renode emulation**
- But the build is TensorFlow-centric
  - Difficult to take out of TensorFlow tree
  - Driven by Makefiles which in the end call Zephyr's build system
- By making it a Zephyr module, we can build it in as a library using Zephyr's simple CMake-based build system
- All you have to do is…
  - Set configuration option for the module in your project configuration file
  - Write a short CMake file

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Demonstration

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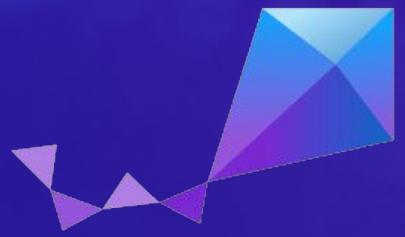
Conclusion



Tips for Application Developers

- Make sure your code doesn't use C++ features not supported by Zephyr
  - Exceptions*
  - Dynamic object management with **new** and **delete**
  - Real time type information
  - Static global object destruction
- Check to see if the board you select is supported
  - Check to see if the sensor you pick has drivers
  - (This may make your life easier!)
- Model your application off the Zephyr TensorFlow Hello World sample
- Ask for help on Slack or the mailing lists
- File bugs or enhancements in GitHub (and tag me)

*Support for exceptions currently a work in progress

Plea for Contributors

Tips for Contributors

- We're looking for:
  - TensorFlow users
  - Windows and Mac users
  - (Experienced or not!)
- Feel free to contribute:
  - Bug fixes
  - Enhancements
  - Samples
  - Kconfig options
  - (And much more!)

```
# Copyright (c) 2021 Intel Corporation (and your company!)
# SPDX-License-Identifier: Apache-2.0

config ZEPHYR_TENSORFLOW_LITE_MICRO_MODULE
    bool

config TENSORFLOW_LITE_MICRO
    bool "TensorFlow Lite Micro Support"
    help
      This option enables the TensorFlow Lite Micro library.

# Your Kconfig options here!
```

- Check out the merged RFC PR that added initial module support
- Check out the TensorFlow Zephyr module repository
- Read the documentation on Zephyr modules

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Questions?
Comments?
Suggestions?
Discuss!

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Sources

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