An Introduction to Building Incremental Dialogue Systems in Python

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What's it about?

This tutorial is for you if...

- ... you want to get a (deeper) understanding what incremental processing is
- ... you already know what incremental processing is, but you never found a good way to integrate it into your system

After the tutorial you will...

- ... understand how the retico python framework works, what it can do and what features we are still working on
- ... have built your first application in the retico python framework!

Demo Time!

Agenda

09:00 - 09:15	Welcome & Introduction
09:15 - 10:00	retico - An Overview of Incremental Processing and the Framework
10:00 - 10:30	Coffee Break
10:30 - 11:15	Hands-On 1: Building a First Dialogue System (Guided Programming) & Extending the System (Solo Work with Individual Help)
11:15 - 11:50	Hands-On 2: Creating New Modules & Incremental Units (Guided Programming) & Advancing the Dialogue System (Solo Work with Individual Help)
11:50 - 12:00	Advanced Features, Future Work & Farewell

Incremental Processing

A quick intro & some background

What retico is...

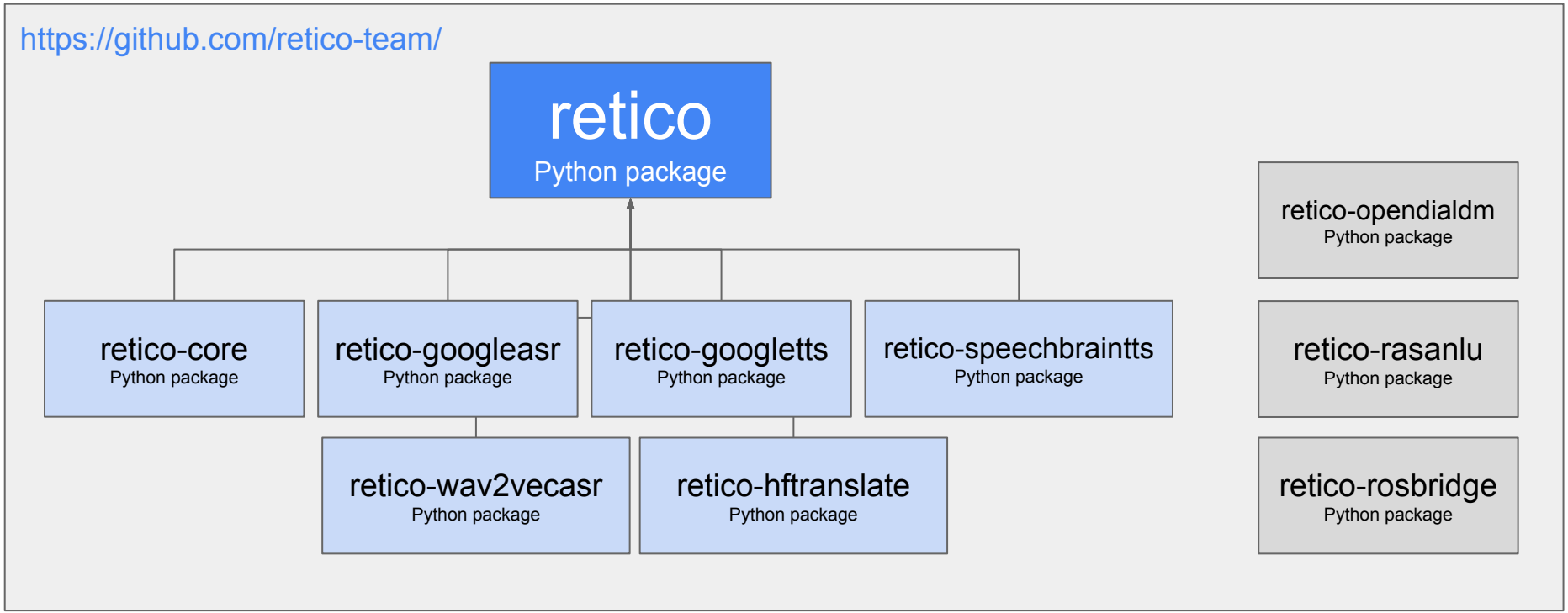
- A framework for incremental dialogue written in python
- A collection of state-of-the-art incremental modules
- An interface for interconnecting incremental systems
- A research tool that is under active development

What retico is not...

- A tool for building dialogue systems (like IBM Watson or Google Dialogflow)
- A finished production-ready project

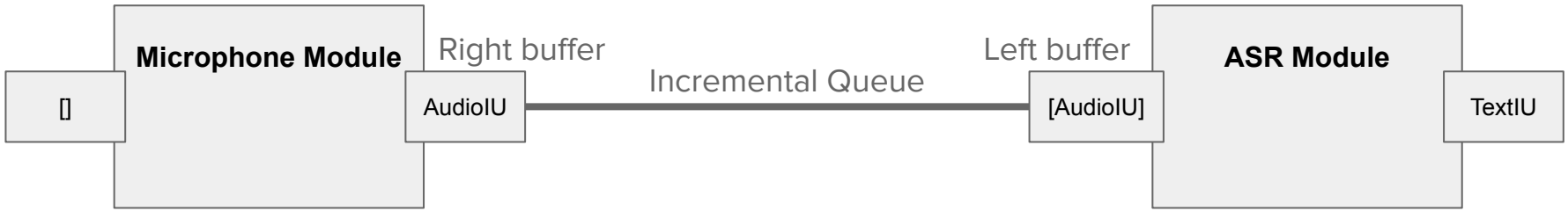
The structure of the retico project

```
from retico import *
```



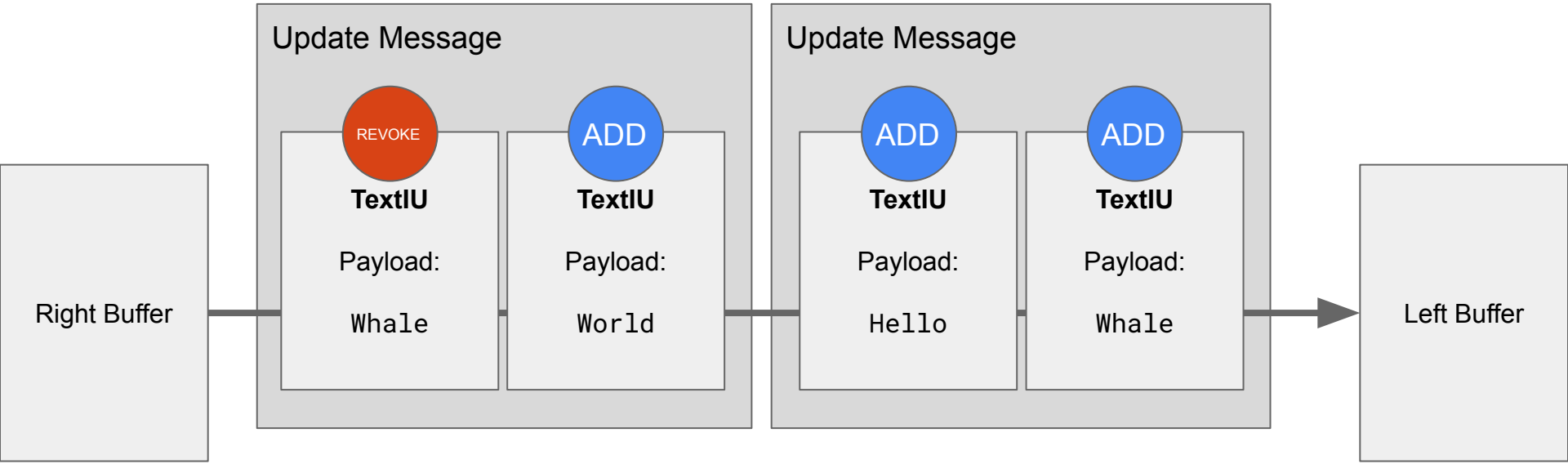
Incremental modules

- All incremental modules inherit from `AbstractIncrementalModule`
- Every module declares a **list of input IU types**, one **output IU type** a **name** and a **description**
- They are connected with the `subscribe` method
  e.g., `microphone_module.subscribe(asr_module)`



Incremental units

- **Incremental units** carry the increments to the connected incremental modules
- Multiple IUs are packaged into **Update Messages**
- Every Incremental Unit has an **Update Type** attached



Creating incremental networks

- Connect the output of a module with the input of another with **`subscribe()`**
- Start the execution of a module with **`run()`**
- Stop the execution of a module with **`stop()`**
- Each incremental module runs in its own *thread*, that means modules run in parallel!

```
from retico import *

modul1 = MyModule1()
modul2 = MyModule2()

modul1.subscribe(modul2)

modul1.run()
modul2.run()

print("Network is running")
input()

modul1.stop()
modul2.stop()
```

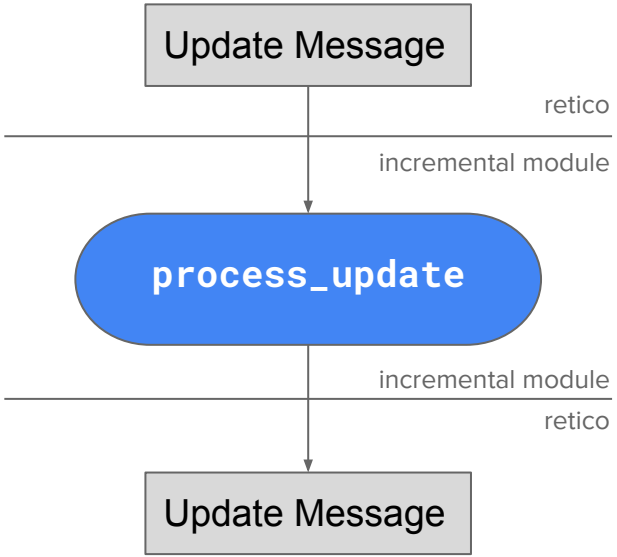
Creating incremental modules

- An incremental module inherits from **`AbstractModule`**
- A module always implements the 4 methods **`name`**, **`description`**, **`input_ius`**, and **`output_iu`**
- An incremental module can process None, 1, or many input_iu types
- An incremental module can process None or exactly 1 output IU type

```
from retico import *

class MyFirstModule(AbstractModule):
    @staticmethod
    def name():
        return "My First Module"

    @staticmethod
    def description():
        return "This module does nothing in particular."

    @staticmethod
    def input_ius():
        return [ius.TextIU, ius.AudioIU, ius.DialogueActIU]

    @staticmethod
    def output_iu():
        return ius.TextIU
```

The process_update method

- Gets called by retico whenever there is a new update message available
- Is responsible for keeping track of the state of the **input**
- Is responsible for producing **new hypotheses**
- Is responsible for keeping track of the state of the **output**
- May return a new update message, containing IUs to be **added, updated, revoked, or committed**



What we need

- Python3, at least 3.10
- The portaudio library
  - For MacOS: **`brew install portaudio ffmpeg`**
  - For Linux (debian-based):
    ```
    sudo apt-get install libasound-dev portaudio19-dev libportaudio2 libportaudiocpp0 ffmpeg
    ```
  - For Windows: Download and install **ffmpeg**
- To install retico:

  ```
  pip3 install --upgrade retico
  ```

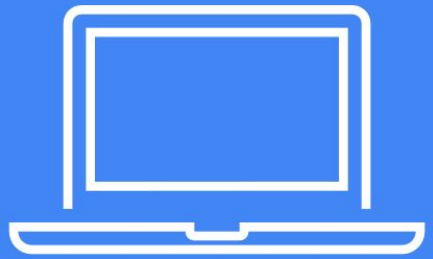
- To check if it worked:

  ```
  import retico
  print(retico.__version__)
  ```

Coffee Break

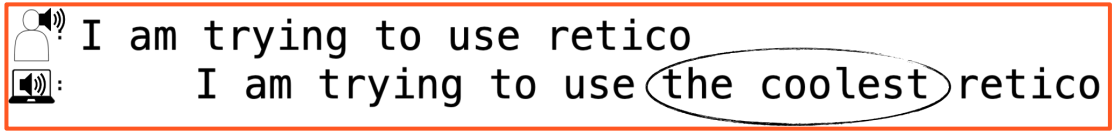
Next up: Hands-On Session
Start: 10:30

Hands-on Part I

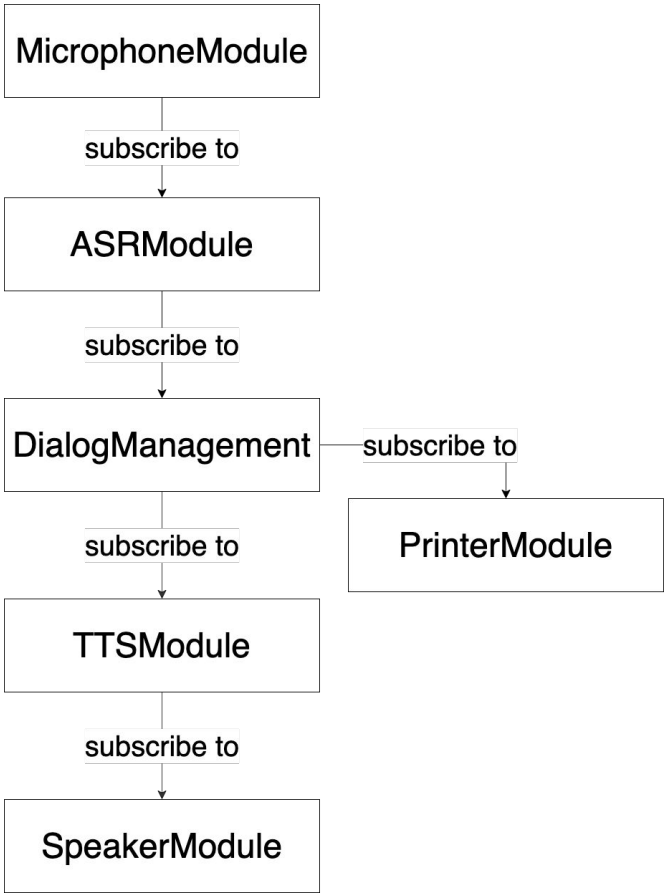


What we'll build

- Network that takes speech as input, replaces/inserts some words, and outputs the result as speech.

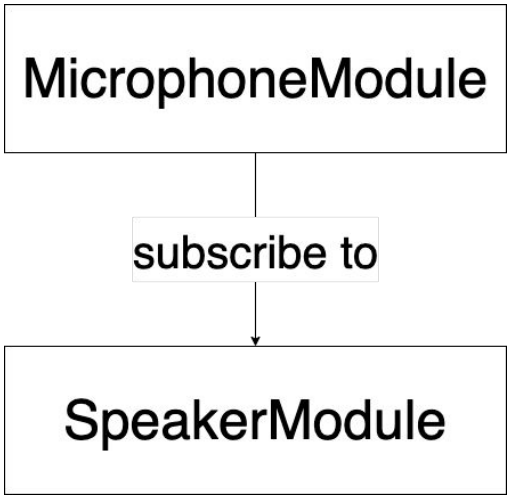


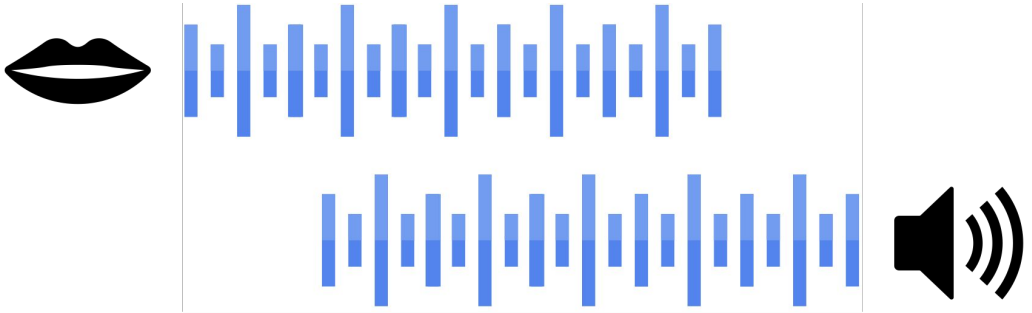
- We will print ASR results to the screen for debugging purposes.
- All the steps: https://github.com/retico-team/konvens-tutorial



Step 1 – Speech in and out

- The first application will be an echo, taking in speech and incrementally playing it back.
- We need two modules:
  one for the input speech stream, one for the output stream.





Step 1 – Speech in and out

- In your favorite editor or IDE: retico_network.py

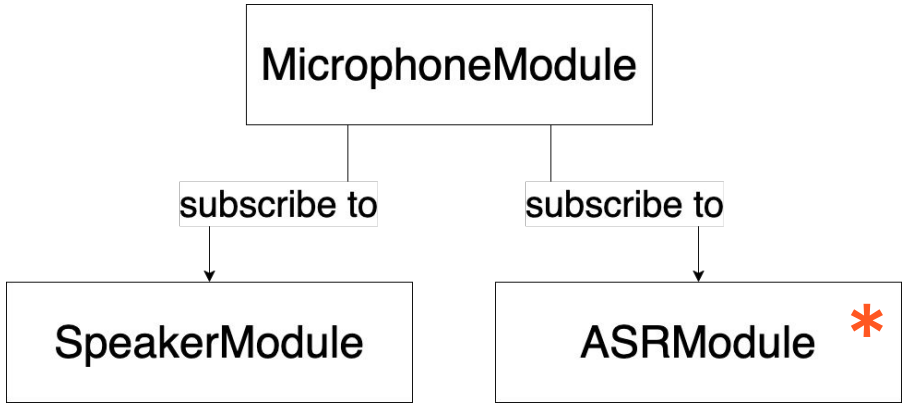
```
1  from retico import *
2
3  microphone = modules.MicrophoneModule()
4  speaker = modules.SpeakerModule()
5
6  microphone.subscribe(speaker)
7
8  run(microphone)
9
10 print("Running the network. Press enter to exit")
11 input()
12
13 stop(microphone)
```

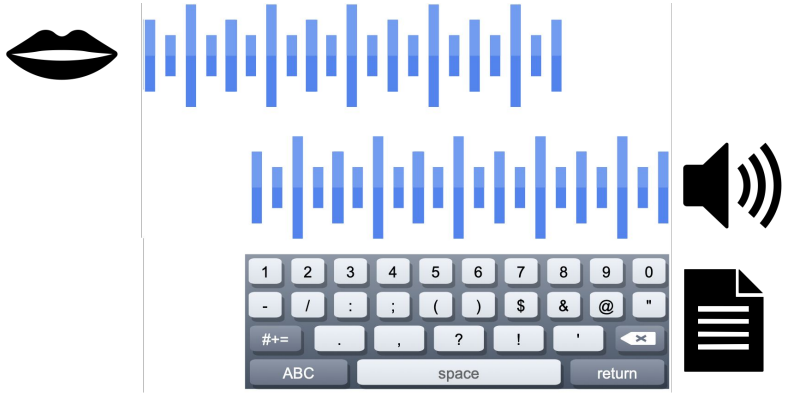
This network can cause a feedback loop, as you output exactly what the microphone records!

Use headphones!!

Step 2 – Speech in and out. And also ASR

- The second application will still do the echo, and will also perform speech recognition.
- We need three modules: one for the input speech stream, one for the output stream, and one for the speech recognition.





Step 2 – Speech in and out. And also ASR

```
1  from retico import *
2
3  microphone = modules.MicrophoneModule()
4  asr = modules.Wav2VecASRModule("en")
5  speaker = modules.SpeakerModule()
6
7  printer_module = modules.TextPrinterModule()
8  asr.subscribe(printer_module)
9
10 microphone.subscribe(speaker)
11 microphone.subscribe(asr)
12
13 run(microphone)
14
15 print("Running the network. Press enter to exit")
16 input()
```

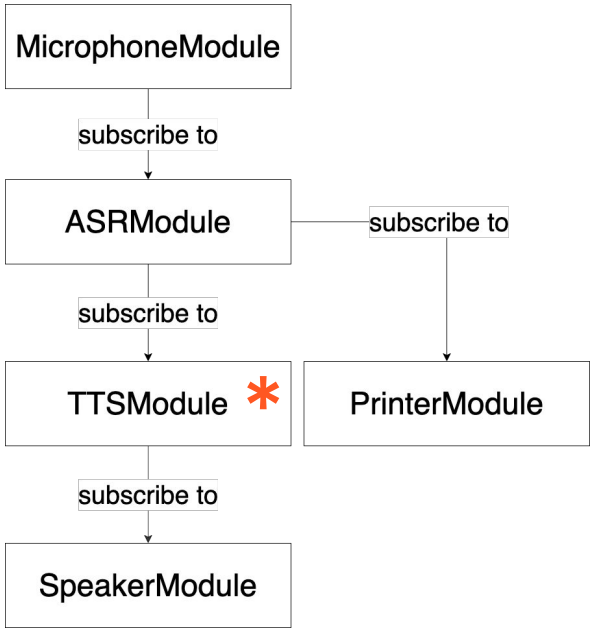
Create asr object for English speech recognition

We need an extra helper module to print ASR results to the terminal.

Add ASR to the network

Step 3 – Adding speech synthesis

- Instead of just playing back the incoming speech, we'll synthesize what the ASR recognized.



Step 3 – Adding speech synthesis

```
1  from retico import *
2
3  microphone = modules.MicrophoneModule(rate=16000)
4  asr = modules.Wav2VecASRModule("en")
5  tts = modules.SpeechBrainTTSModule("en")
6  speaker = modules.SpeakerModule(rate=22050)
7
8  printer_module = modules.TextPrinterModule()
9  asr.subscribe(printer_module)
10
11 # Build the new network
12 # microphone.subscribe(speaker)
13 microphone.subscribe(asr)
14 asr.subscribe(tts)
15 tts.subscribe(speaker)
16
17 run(microphone)
18 print("Running the network. Press enter to exit")
19 input()
20 stop(microphone)
```

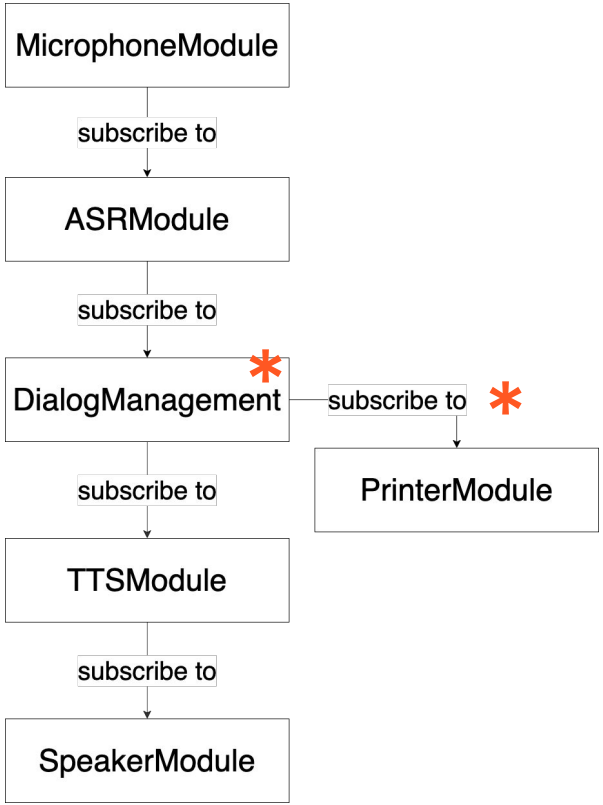
Create the TTS object and set the speech rate for the speaker output

Adjust the network

Step 4 – Adding simple dialog management

- Let’s change some words before synthesis.
- Writing your own module.

- A module that takes text and returns text, replacing every instance of “you” with “I” (or anything else you want to replace).



Step 4 – Adding simple dialog management

```
37  microphone = modules.MicrophoneModule(rate=16000)
38  asr = modules.Wav2VecASRModule(language="en")
39  wordchanger = WordChangerModule(word_map={"you": "I"})
40  printer = modules.TextPrinterModule()
41  tts = modules.SpeechBrainTTSModule(language="en")
42  speaker = modules.SpeakerModule(rate=22050)
43
44  microphone.subscribe(asr)
45  asr.subscribe(wordchanger)
46  wordchanger.subscribe(printer)
47  wordchanger.subscribe(tts)
48  tts.subscribe(speaker)
```

We'll insert a module that takes a mapping as input, specifying what to change.

We'll move the printer module to after the change.

Step 4 – Writing your own module

```
4  class WordChangerModule(AbstractModule):
5      @staticmethod
6      def input_ius():
7          return [ius.TextIU]
8
9      @staticmethod
10     def output_iu():
11         return ius.TextIU
12
13     def __init__(self, word_map, **kwargs):
14         super().__init__(**kwargs)
15         self.word_map = word_map
```

We'll extend the AbstractModule class.

We want text as input and output incremental units.

And we'll add the word replacement mapping as attribute.

Step 4 – Writing your own module

```
def process_update(self, update_message):
    new_update_message = UpdateMessage()
    for incremental_unit, update_type in update_message:
        # replace strings here

        new_update_message.add_iu(incremental_unit, update_type)
    return new_update_message
```

We need to implement this method that takes the update_message and returns a new update message

Step 4 – Writing your own module

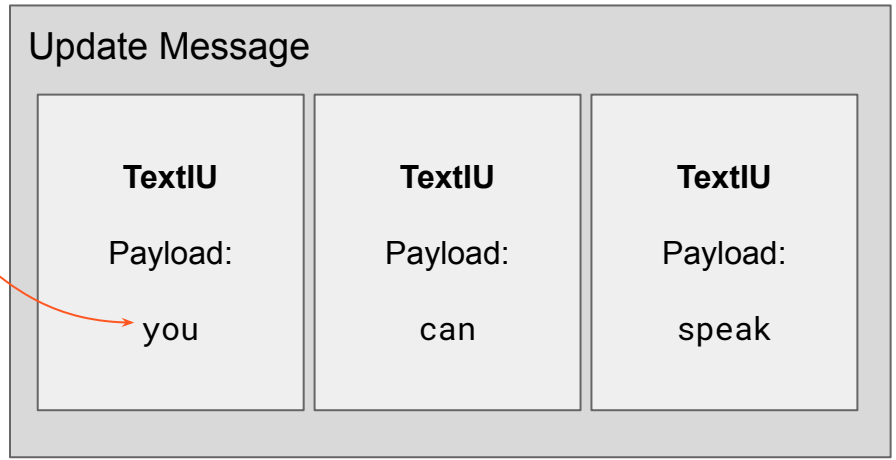
```
def process_update(self, update_message):
    new_update_message = UpdateMessage()
    for incremental_unit, update_type in update_message:
        # replace strings here

        new_update_message.add_iu(incremental_unit, update_type)
    return new_update_message
```

We need to implement this method that takes the update_message and returns a new update message

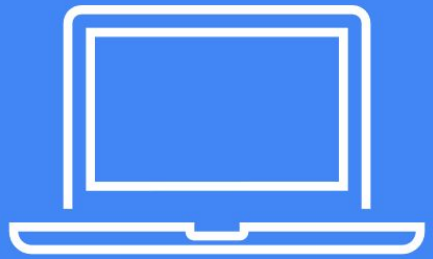
- `incremental_unit` is of type TextIU
- TextIU Payloads are named `.text`

`incremental_unit.text`

- Our replacement dictionary is called `self.word_map`

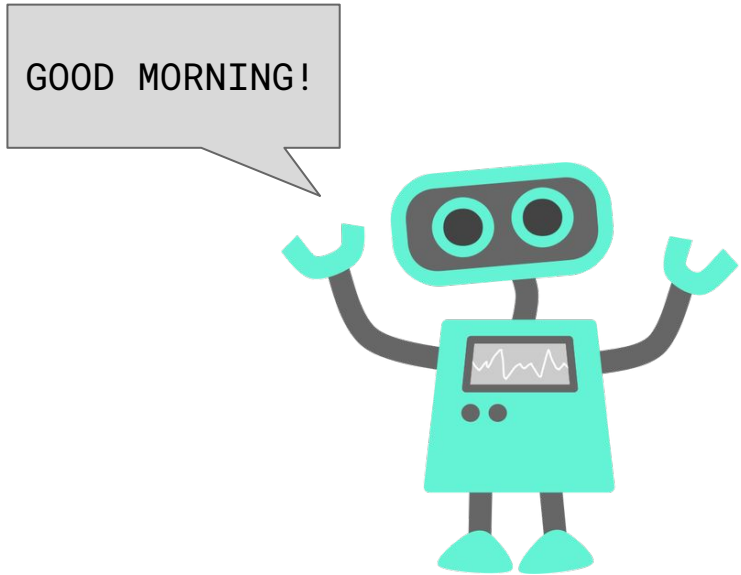


Hands-on Part II



What we'll build

A translation module based on a hugging face transformer network that incrementally translates between different languages



Step 1: HF Translator

- Retico has a helper class called **HFTranslate** that translates non-incrementally between different languages!

```
from retico import *

translator = helper.HFTranslate(from_lang="en",to_lang="de")
print(translator.translate("Hello KONVENS, this is a test."))
```

- Make yourself comfortable with this helper class!

- English to French
- French to English
- English to German
- German to English
- Spanish to English
- English to Spanish
- French to German
- German to French

Step 2: Creating the incremental module

- Input and output will be **`TextIU`**s

- In the initializer we instantiate the HFTranslate module

```
from retico import *

class TranslationModule(AbstractModule):
    @staticmethod
    def name():
        return "Translation Module from the KONVENS 2022 retico tutorial"

    @staticmethod
    def description():
        return "A module that translates between languages."

    @staticmethod
    def input_ius():
        return [ius.TextIU]

    @staticmethod
    def output_iu():
        return ius.TextIU

    def __init__(self, **kwargs):
        super().__init__(**kwargs)
        self.translator = helper.HFTranslate("en", "de")
```

Step 3: Handling incoming units

```
def process_update(self, update_message):
    for incremental_unit, update_type in update_message:
        if update_type == UpdateType.ADD:
            self.current_input.append(incremental_unit)
        elif update_type == UpdateType.REVOKE:
            self.revoke(incremental_unit)
        elif update_type == UpdateType.COMMIT:
            self.commit(incremental_unit)
```

- **`current_input`** is a list of IUs that are currently being used to form a new output hypothesis (in this case the translation).
- **`revoke()`** flags the incremental unit as revoked and deletes it from the **`current_input`** list
- **`commit()`** flags the incremental unit as committed but does *not* delete it from the **`current_input`** list

Step 4: Constructing the current text

```
current_text = " ".join([iu.text for iu in self.current_input])
current_translation = self.translator.translate(current_text)
```

- The **`current_text`** is constructed by joining together all words in the **`current_input`** list
- With the translator, the complete text is translated into the target language
- **`current_translation`** is the complete translation and needs to be incrementalized depending on the IUs that were already published by the module

Step 5: Turning translations into increments

Example:

current_output

TextIU **The**

TextIU **quick**

TextIU **bright**

Current_translation

The quick brown fox

Expected output:

REVOKE

TextIU **bright**

ADD

TextIU **brown**

ADD

TextIU **fox**

Step 5: Turning translations into increments

```
update_msg, new_tokens = helper.get_text_increment(self, current_translation)
```

Helper function takes as arguments

- the module that contains the current output IUs (stored in **`current_output`**)
- the current translation from which the *difference* should be computed

Helper function returns

- update message with IUs that should be **revoked**
- list of new tokens (words) that should be turned into **incremental units** and **added**
- And it removes the revoked functions from the **`current_output`** of the module

Step 6: Adding new tokens

```
for token in new_tokens:
    new_iu = self.create_iu(grounded_in=incremental_unit)
    new_iu.text = token
    self.current_output.append(new_iu)
    update_msg.add_iu(new_iu, UpdateType.ADD)
```

- Create new IU with the **`create_iu`** function
  - Specify the IU that the new one is *grounded in*
- Set the text to be the new token
- Add the IU to the **`current_output`**
- Add the IU to the update message

Step 7: Cleaning when IUs are committed

```
if self.input_committed():
    for iu in self.current_output:
        self.commit(iu)
        update_msg.add_iu(iu, UpdateType.COMMIT)
    self.current_input = []
    self.current_output = []

return update_msg
```

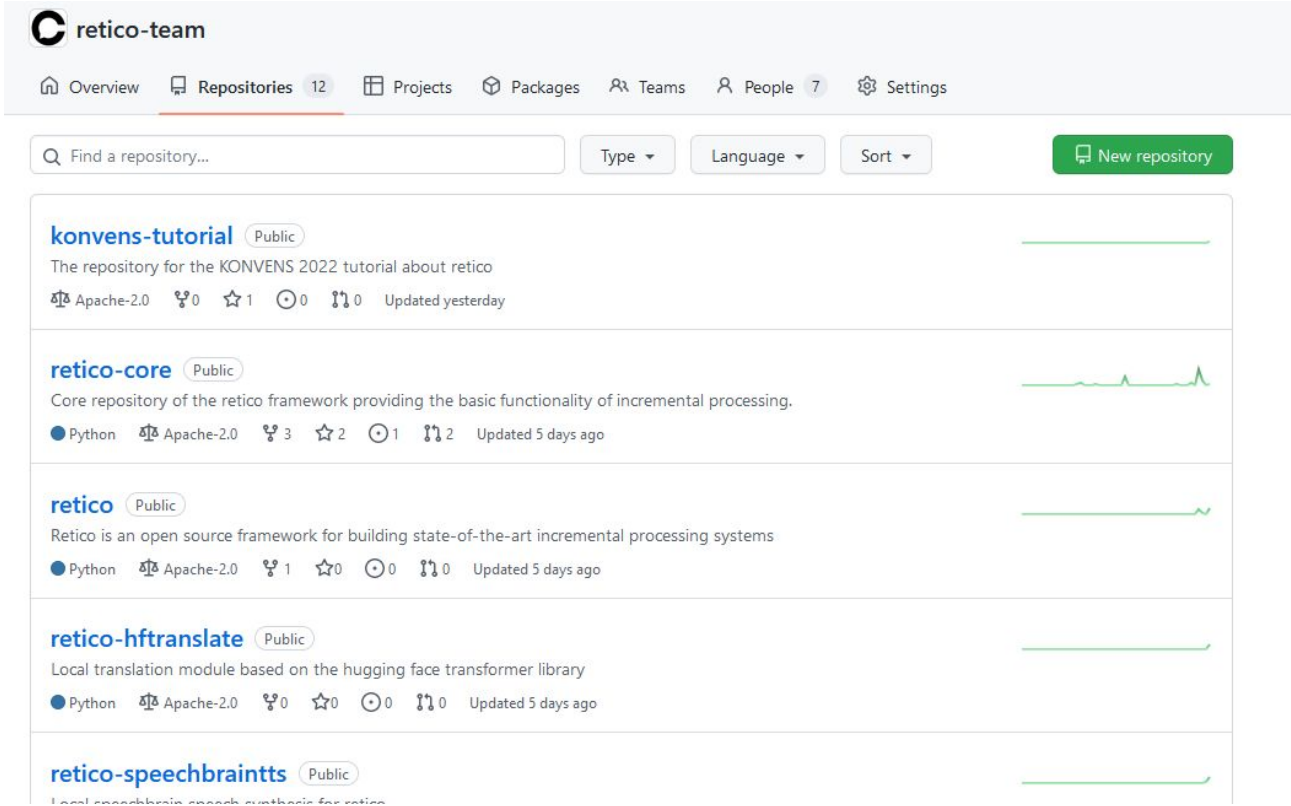
- The **`input_committed`** method checks if all IUs in the **`current_input`** are committed
- All IUs are flagged as committed and added to the update message
- **`current_input`** and **`current_output`** are cleared

Step 8: Creating the network

```
microphone = modules.MicrophoneModule(rate=16000)
asr = modules.Wav2VecASRModule(language="en")
translation = TranslationModule()
printer = modules.TextPrinterModule()

microphone.subscribe(asr)
asr.subscribe(translation)
translation.subscribe(printer)

run(microphone)

print("Network is running")
input()

stop(microphone)
```

Advanced Features & Future Work

retico on GitHub



Advanced Features

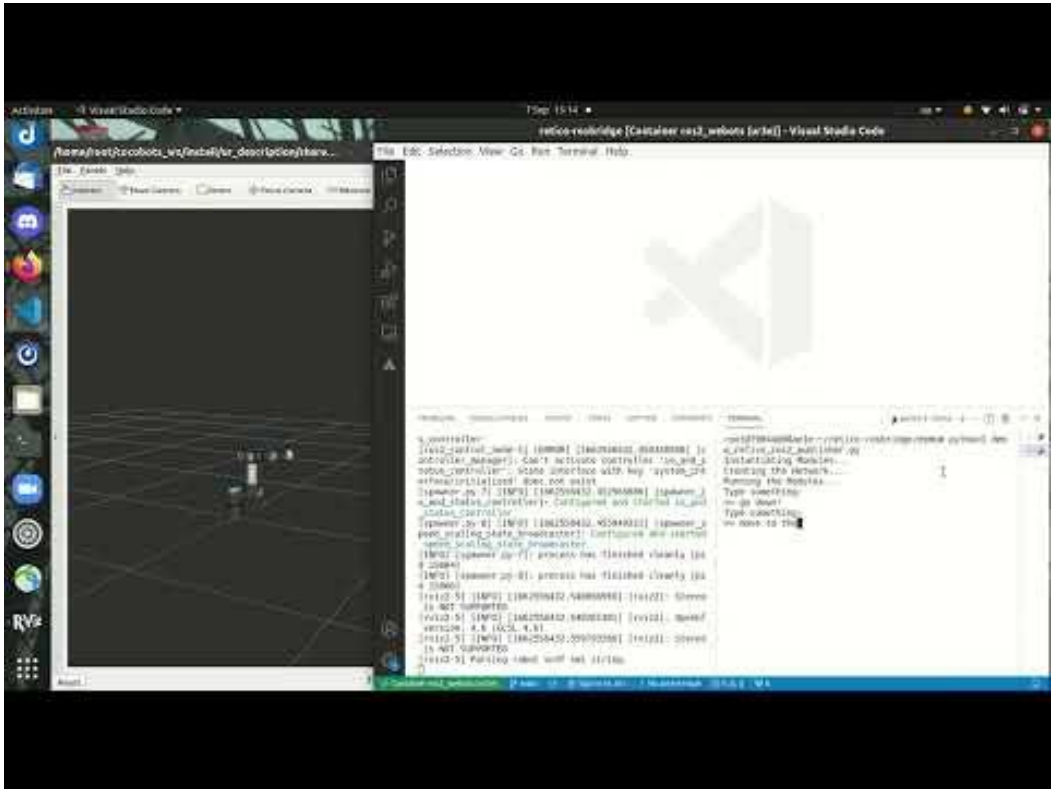
An incremental implementation of Rasa NLU
(Rafla & Kennington, 2019)

Google ASR and TTS System

ZeroMQ for asynchronous messaging between processes

OpenDial Dialogue Management
(Lison & Kennington, 2016)

Integration with Robot Operating System



ROS

Future Plans

Currently under development

- Integration with Microsoft Platform for Situated Intelligence (PSI)
- Adding further sensor input possibilities
  - Webcams
  - RealSense camera
  - Microsoft Kinect
- OpenFace to process camera images

Future Plans

Creating a framework for **teaching** dialogue system development by including

- Tutorials & training videos
- Tasks and sample solutions
- Graphical User Interface

Missing any features?
Have a question?
Need help getting started?

Get in touch on GitHub!

https://github.com/retico-team/retico

Technische Universität Berlin

Universität Potsdam