Solutions Engineer Interview Exercise

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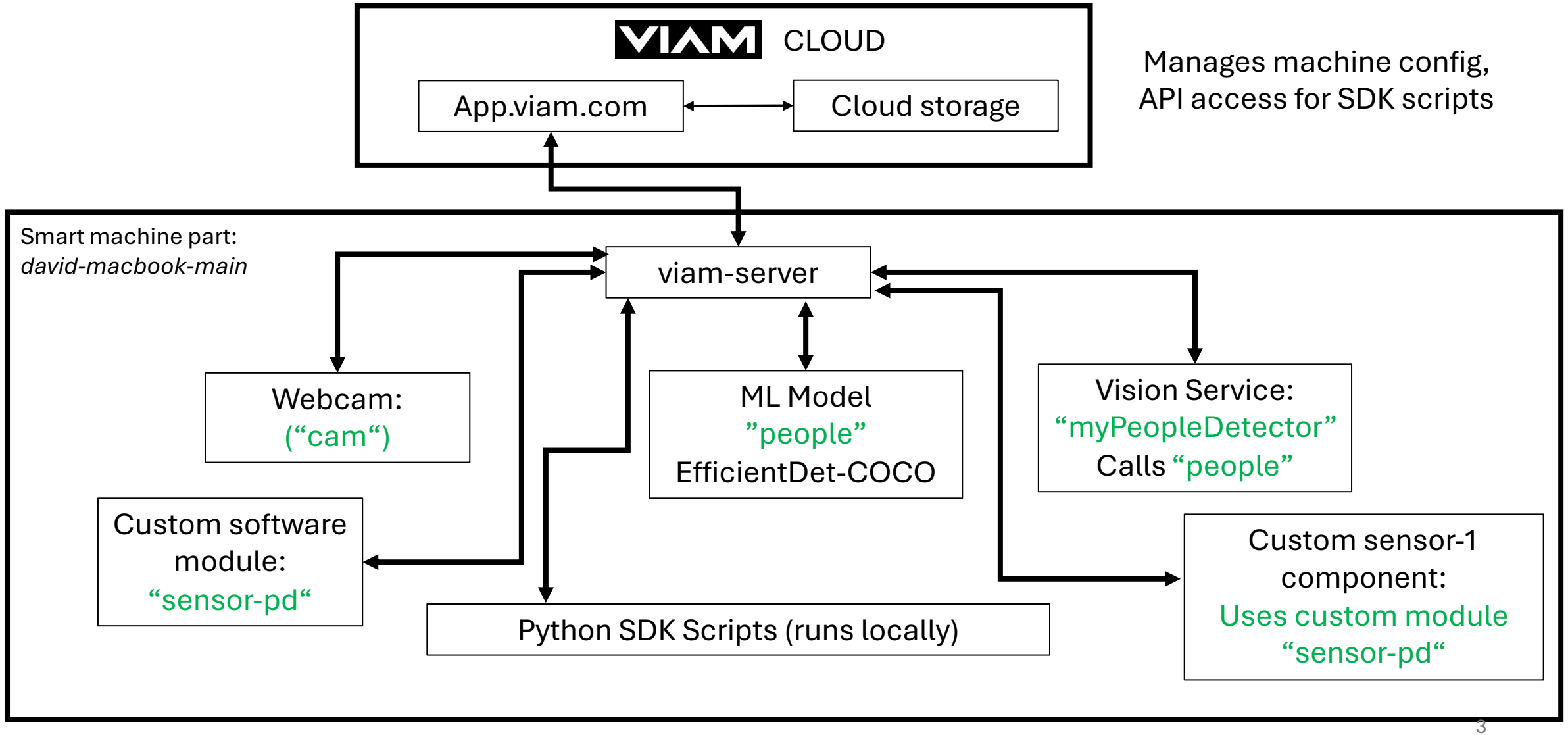
Overview of the Project

- Task 1: Vision
  - Configure a basic camera component and use Viam's vision service to implement a simple object detector
- Task 2: Cloud Integration
  - Configure Viam's data capture service to store camera frames into the cloud
  - How could we use this data to possibly create a custom model?
- Task 3: Modular Registry
  - Create a custom sensor (calling the previously created vision service)
  - Should have a single field called "person detected"
  - Set to 1 if a person is detected, and 0 if no person is detected

Platform architecture

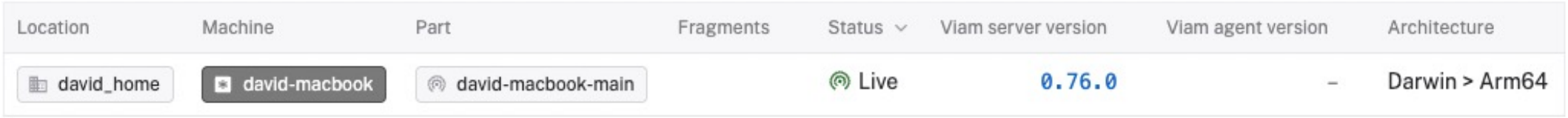


Overview of the Project Directory

Project Structure

```
viam-interview-project/
├── camera_vision/          # Task 1: Vision service test script
├── sensor-pd/              # Task 3: Custom person-detection sensor module
├── screenshots/            # Screenshots/notes documenting steps for Tasks 1,2,3
├── slides/                 # Presentation deck for final submission
├── README.md               # This file
└── .gitignore              # Ignores virtual environments, cache, etc.
```

From GitHub README: https://github.com/djlev8/viam-interview-project/tree/main



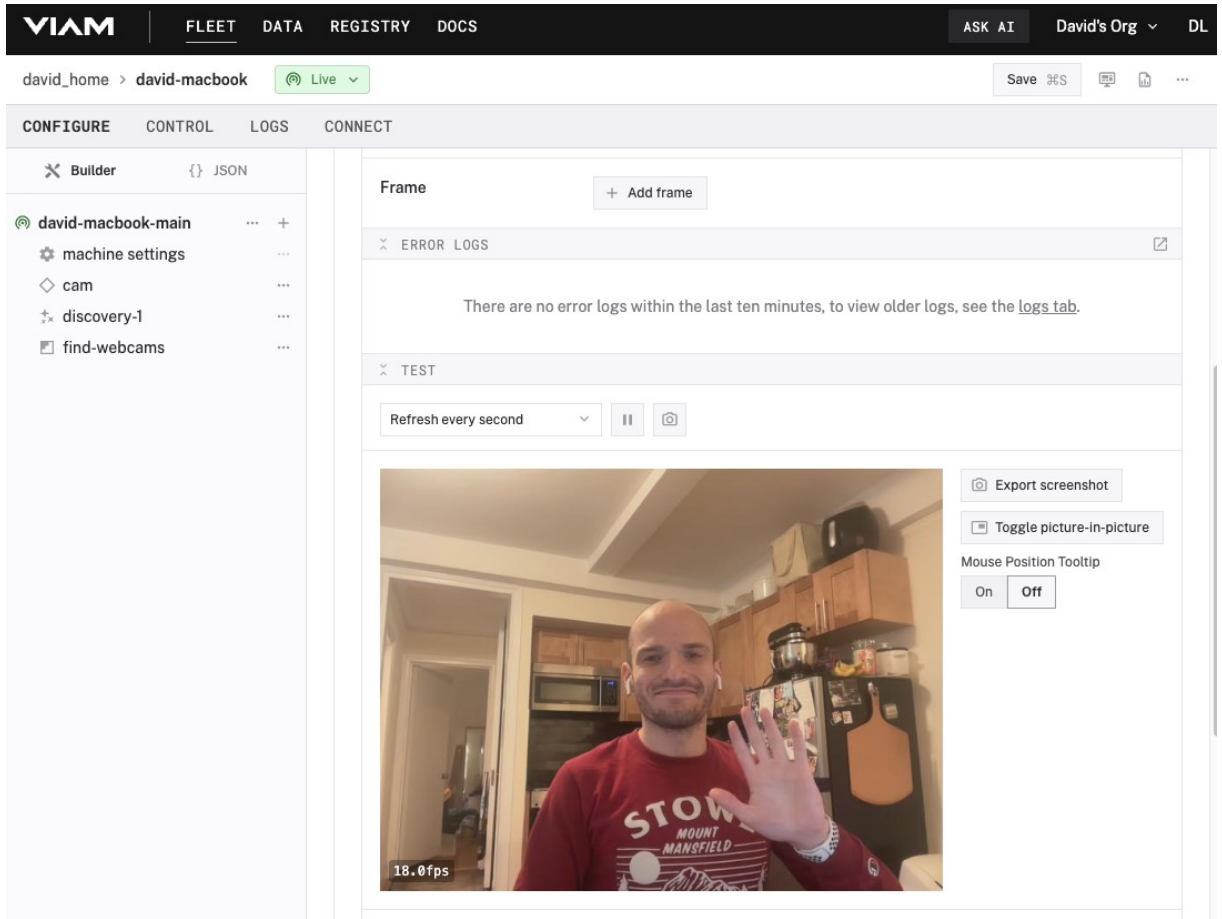
From Viam dashboard

Task 1: Vision Service and Object Detection

Following the ‘Detect a Person and Send a Photo’ tutorial.

Goal: **Set up a webcam** → ML model (EfficientDet-COCO) → Vision Service → SDK-based person detection

Configured webcam test



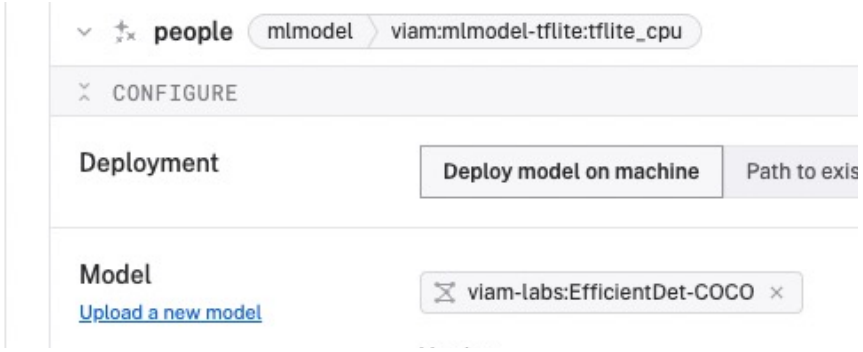
Configured webcam JSON

```json
{
  "components": [
    {
      "name": "cam",
      "api": "rdk:component:camera",
      "model": "rdk:builtin:webcam",
      "attributes": {
        "video_path": "FDF90FEB-59E5-4FCF-AABD-DA03C4E19BFB"
      }
    }
  ],
  "services": [
    {
      "name": "discovery-1",
      "api": "rdk:service:discovery",
      "model": "rand:find-webcams:webcam-discovery",
      "attributes": {}
    }
  ],
  "modules": [
    {
      "type": "registry",
      "name": "rand_find-webcams",
      "module_id": "rand:find-webcams",
      "version": "latest"
    }
  ]
}
```

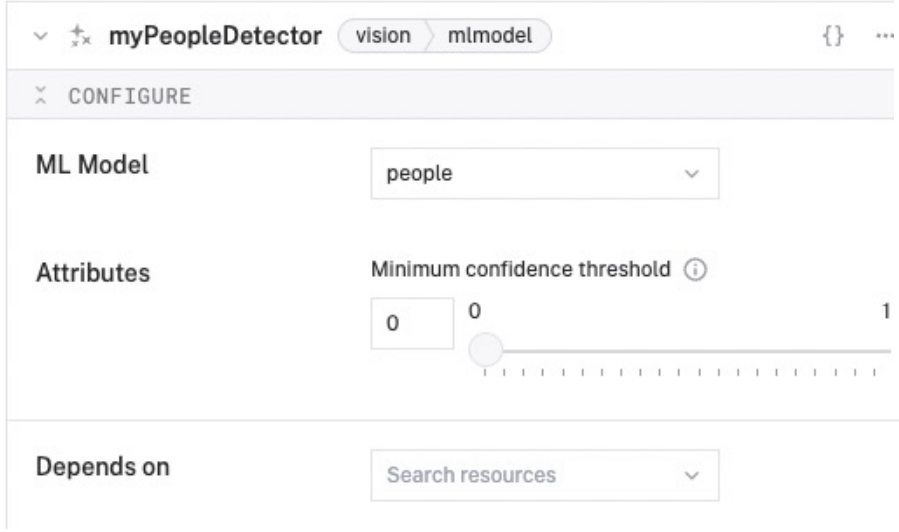
Task 1: Vision Service and Object Detection

Goal: Set up a webcam → **ML model (EfficientDet-COCO)** → **Vision Service** → SDK-based person detection

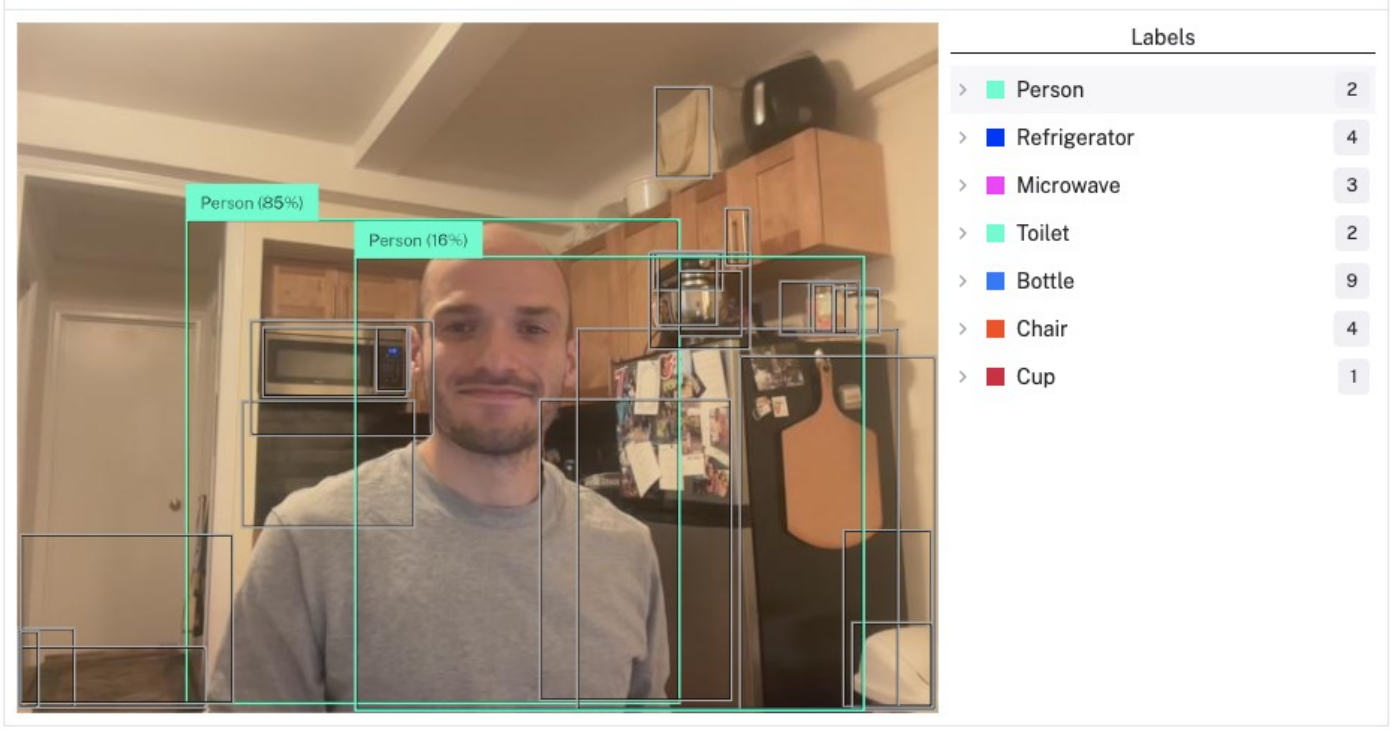
EfficientDet-COCO model deployed



Vision Service created and linked to model



Detection UI



Task 1: Vision Service and Object Detection

Goal: Set up a webcam → ML model (EfficientDet-COCO) → Vision Service → **SDK-based person detection**

Terminal Output: Person Detected

```
.venv(base) davidlevine@Davids-Air-3 camera_vi
2025-05-24 13:10:50,912          INFO    viam.r
Resources:
[<viam.proto.common.ResourceName rdk:service:d
/myPeopleDetector at 0x10521dbc0>, <viam.proto
urceName rdk:service:mlmodel/people at 0x10521
detected_people: [x_min: 166
y_min: 170
x_max: 556
y_max: 479
confidence: 0.83984375
class_name: "Person"
```

Code snippet from detection script (vision_service.py)

```python
    # myPeopleDetector
    my_people_detector = VisionClient.from_robot(machine, "myPeopleDetector")
    #my_people_detector_return_value = await my_people_detector.get_properties()
    #print(f"myPeopleDetector get_properties return value: {my_people_detector_return_value}")

    detected_people = [
        person for person in (await my_people_detector.get_detections_from_camera("cam"))
        if person.confidence > 0.5 and person.class_name == "Person"
    ]
    print(f"detected_people: {detected_people}")

    # Don't forget to close the machine when you're done!
    await machine.close()
```

Used SDK to filter for confident (> 0.5) ‘Person’ detections, instead of printing all detections found, regardless of class name or confidence

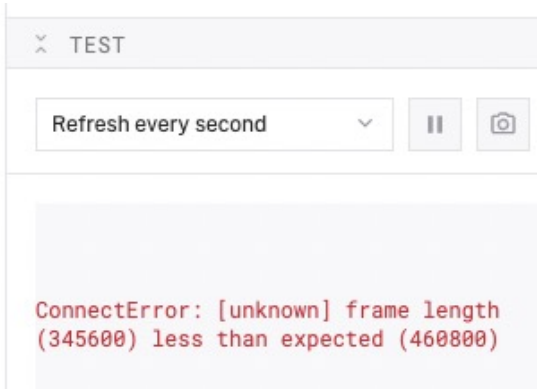
Task 1: Vision Service and Object Detection

Challenges & Debugging:

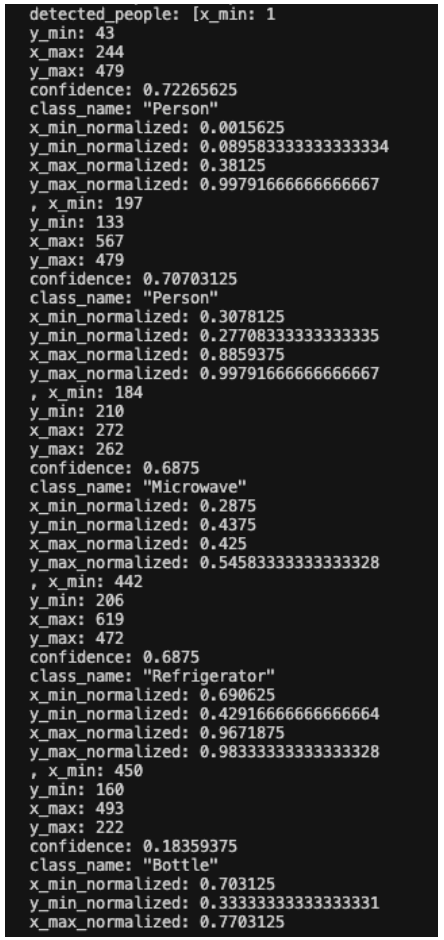
- Encountered webcam connection error
  - Restarted viam-server and reconnected successfully
  - CLI: `viam-server -config ~/Downloads/viam-david-macbook-main.json`

- Needed to use discovery service to retrieve valid video path for my built-in webcam

- Filtered through list of detections to find confident ‘person’ only detections after first obtaining all detections



Webcam connect error



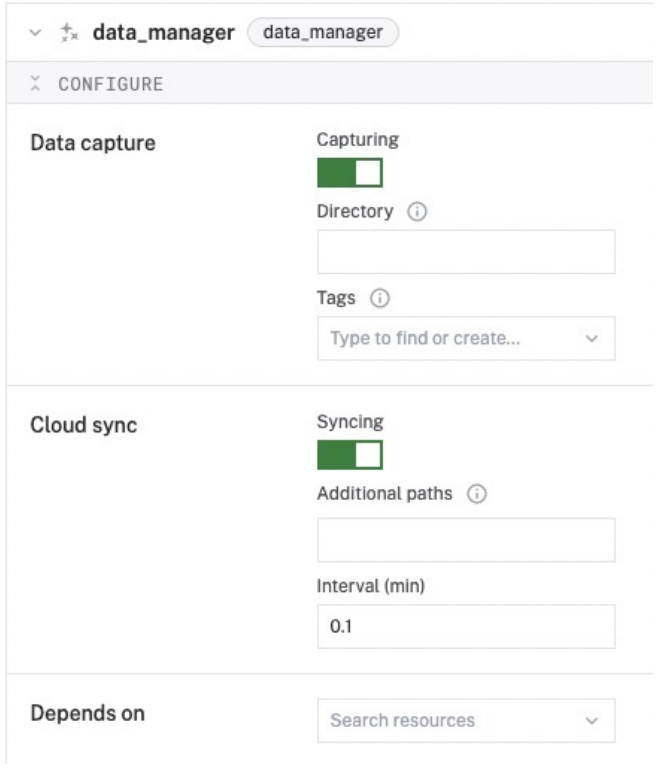
Initial output: Detecting many objects

Task 2: Data Capture & Cloud Storage

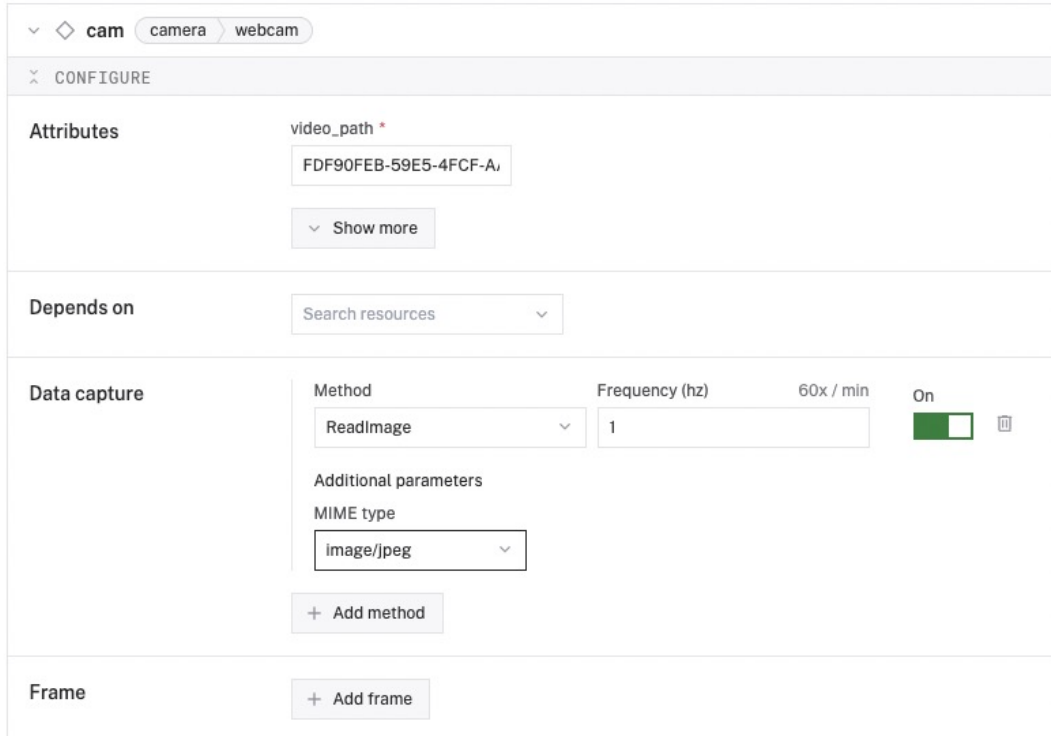
Following the ‘Capture and sync edge data’ document.

Goal: **Create data-manager service → Set capture rate & ReadImage method** → Store frames to cloud

Data management service enabled



Data capture settings specified (capture rate = 1 Hz, MIME type = JPG)

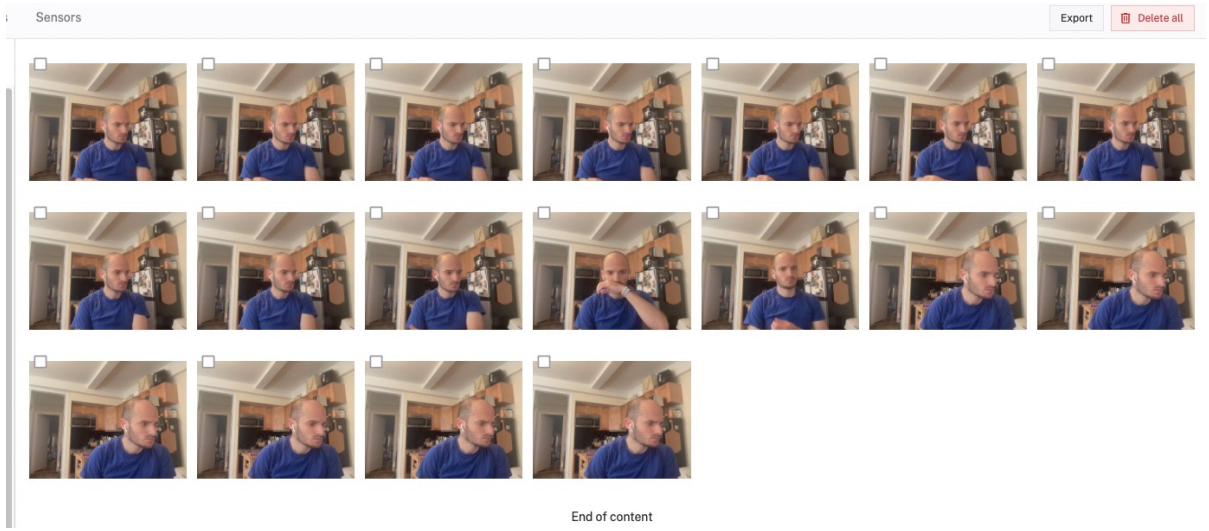


Note: Needed to create data management service prior to configuring data capture with configured camera.

Task 2: Data Capture & Cloud Storage

Goal: Create data-manager service → Set capture rate & ReadImage method → **Store frames to cloud**

Images stored to the cloud



Installed viam CLI to run image export

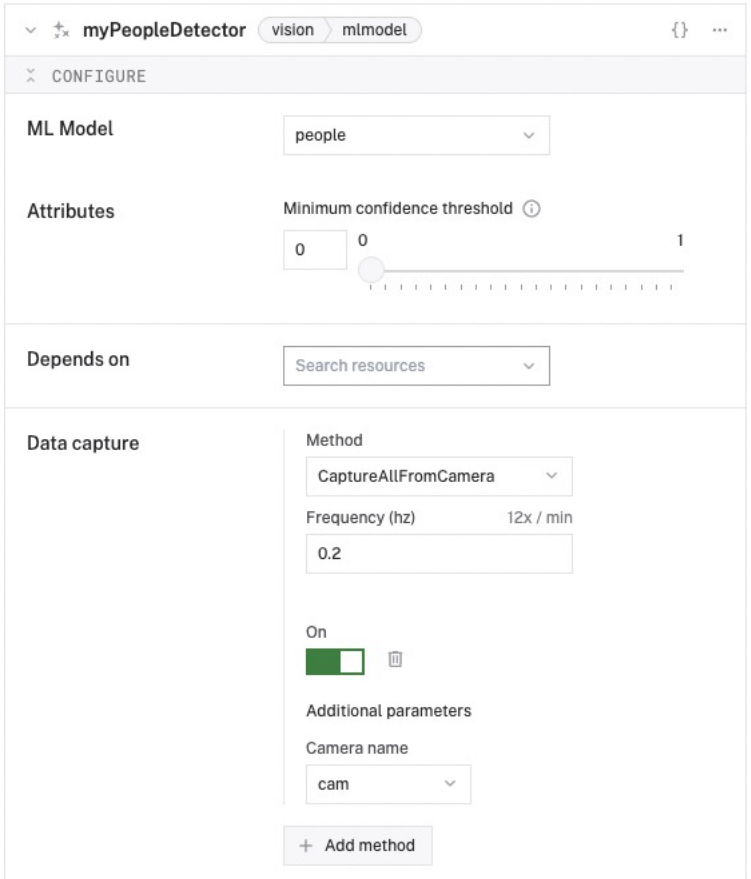
```
(base) davidlevine@Davids-Air-3 ~ % brew tap viamrobotics/brews
brew install viam
==> Auto-updating Homebrew...
Adjust how often this is run with HOMEBREW_AUTO_UPDATE_SECS or disable with
HOMEBREW_NO_AUTO_UPDATE. Hide these hints with HOMEBREW_NO_ENV_HINTS (see `man brew`).
==> Downloading https://ghcr.io/v2/homebrew/portable-ruby/portable-ruby/blobs/sha256:fd162df7a06190ee800a9e6afd28f4466d33548821a480ba043cd927b44d60f7
######################################################################## 100.0%
==> Pouring portable-ruby-3.4.4.arm64_big_sur.bottle.tar.gz
==> Auto-updated Homebrew!
Updated 2 taps (homebrew/core and homebrew/cask).
==> New Formulae
addons-linter       erlang@27           miniprot            style-dictionary
alejandra           fastga              oxen                sylph
autocycler          gcc@14              qnm                 webdav
boa                 gcli                readsb
concurrentqueue     goshs               rna-star
cram                hyper-mcp           shamrock
==> New Casks
font-formudpgothic  font-matangi        lobehub             zoo-design-studio

You have 2 outdated formulae installed.

==> Downloading https://ghcr.io/v2/viamrobotics/brews/viam/manifests/0.76.0-3
######################################################################## 100.0%
==> Fetching viamrobotics/brews/viam
==> Downloading https://ghcr.io/v2/viamrobotics/brews/viam/blobs/sha256:0977a828
######################################################################## 100.0%
==> Installing viam from viamrobotics/brews
==> Pouring viam--0.76.0.arm64_sonoma.bottle.3.tar.gz
🍺  /opt/homebrew/Cellar/viam/0.76.0: 6 files, 42.7MB
==> Running `brew cleanup viam`...
Disable this behaviour by setting HOMEBREW_NO_INSTALL_CLEANUP.
Hide these hints with HOMEBREW_NO_ENV_HINTS (see `man brew`).
(base) davidlevine@Davids-Air-3 ~ % viam login
Info: You can log into Viam through the opened browser window or by following the URL below.
Ensure the code in the URL matches the one shown in your browser.
  https://auth.viam.com/oauth2/device?user_code=LDJ5LX

@@BO..    "%@@B^%@@<      .}j.      !B@B$v'.    'nB$$$!
.*@$%1   f$$@X  %$$+      &@$$      1$$$$@@^   "B$$$$@!
  (@$$@'M@$@:   B$$~    ~B$$@$@1    !$$BQ@@@q.0@$$@@$$!
   'WB$$B@p     B$$~   qB$%~!@@@o.  1$@B..B@$@$@%; @$@!
    .u$$$!      B$$~ ;@@@& ... oB$@~!!$$@. z$$$z'. $$$!
      :h'       B$$~L%@$||     ~@@$bi$@B    'M'    $$$!

Logged in as "david.j.levine8@gmail.com", expires Tue May 27 09:44:10 EDT 2025
(base) davidlevine@Davids-Air-3 ~ % viam data export binary --mime-types=image/jpeg,image/png --org-ids=649e1748-312e-4cb7-830c-cf4c3c5ded08 --destination=.
Downloaded 100 files
Downloaded 200 files
Downloaded 246 files
(base) davidlevine@Davids-Air-3 ~ %
```

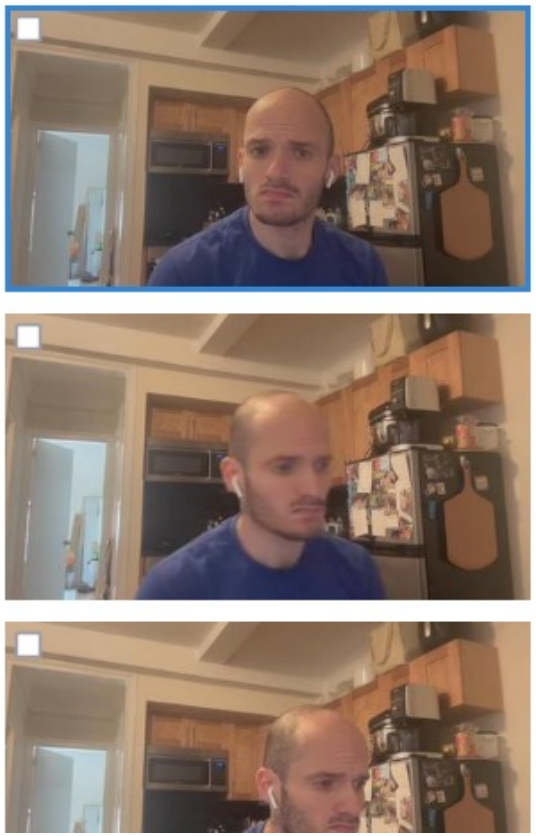
```
viam data export --robot-id <robot-id> --component-name cam --method
ReadImage --output ./exported_data
```

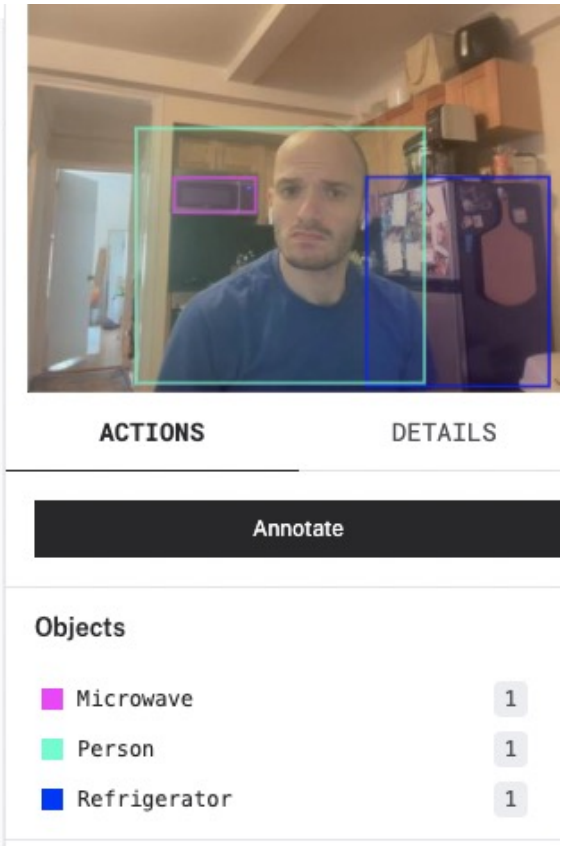
Task 2: Data Capture & Cloud Storage

Goal: Create data-manager service → Set capture rate & ReadImage method → **Store frames to cloud**

Images stored to the cloud with detection details from myPeopleDetector Vision service







Task 2: Discussion – How the data enables custom models

I enabled cloud logging for the cam component, which allowed me to capture image frames from my MacBook's webcam directly to the Viam cloud.

This type of captured image data is valuable for:

- Evaluating model accuracy: comparing what the model detects vs what's actually in the frame.
- Labeling custom datasets: using stored images and metadata to label people or other objects.
- Retraining or fine-tuning models: creating a customer-specific version of EfficientDet-COCO that performs better on their environment or edge cases.

Exported image data and detection logs can be used to train or validate models in frameworks like PyTorch, TensorFlow, or AutoML pipelines.

Going forward, combining image data with detection metadata (e.g., bounding boxes + class + confidence) provides a complete training set for a custom object detector.

Task 3: Modular Registry: Overview

Following the ‘Integrate other physical or virtual hardware’ document.

Goal: Build a custom sensor module that uses the Vision service I previously created and returns:

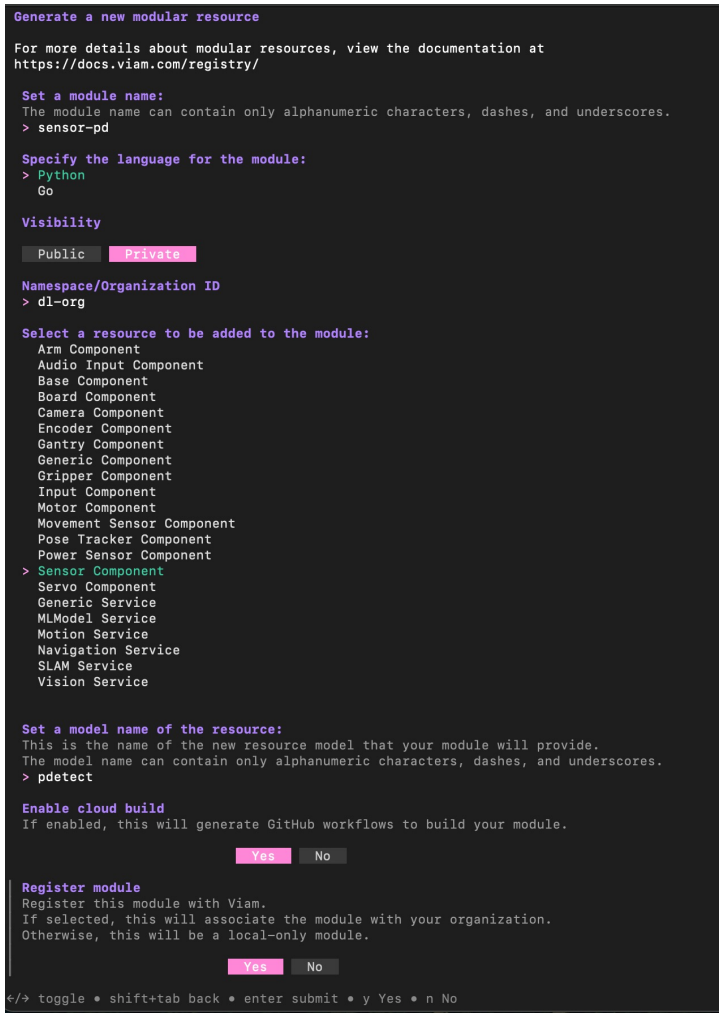
{’person_detected’: 1} if a person is visible to the camera,
and
{’person_detected’: 0} if a person is NOT visible to the camera.

Steps:

1) Module Setup
2) Implementation of the Component API
3) Adding the Custom Sensor Component to my Machine
4) Local Testing
5) Error Handling & Fixes

Task 3: Modular Registry: Module Setup

Goal: Scaffold and generate the custom module, generating the necessary stub files (in the sensor-pd folder).



Module successfully generated!

```
Module successfully generated at sensor-pd
(base) davidlevine@Davids-Air-3 ~ %
```

Prompts filled:

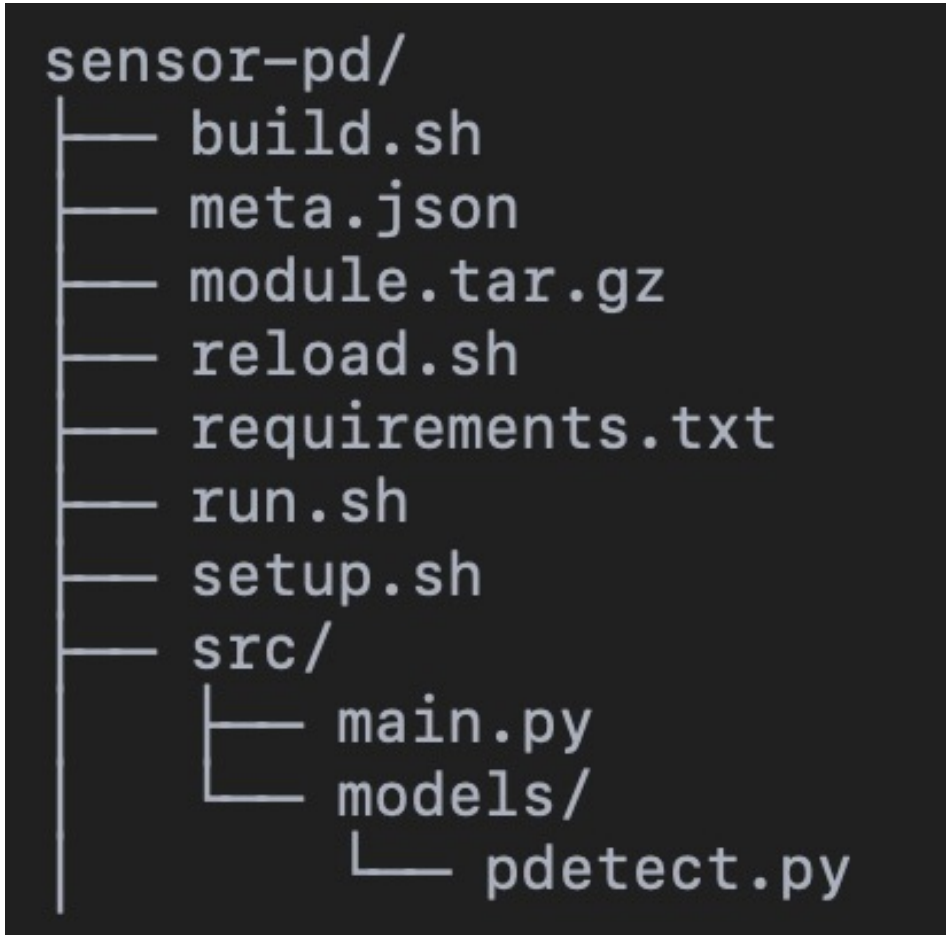
Name: **sensor-pd**
Language: **Python**
Visibility: **Private**
Namespace/Org-ID: **dl-org**
Resource to be added: **Sensor Component**
Model name: **pdetect**
Cloud build? **Yes**
Register module? **Yes**

From the CLI, I used `viam module generate` and followed the relevant prompts.

Task 3: Modular Registry: Module Setup

Goal: Scaffold and generate the custom module, generating the necessary stub files (in the sensor-pd folder).

Final file structure within the generated sensor-pd folder:



I added or changed files from the auto-generated structure to implement my custom sensor logic and enable local development and testing:

- reload.sh **(I added)**
  - Script I wrote for **hot reloading** the module locally.
- meta.json **(I modified)**
- src/models/pdetect.py **(I modified)**
- src/main.py **(I modified)**

Module Architecture: How main.py Registers and Runs the Custom Sensor

- main.py is launched by reload.sh.
  - It loads the module via Module.from_args().
  - Registers my sensor model (dl-org:sensor-pd:pdetect) into Viam's resource registry.

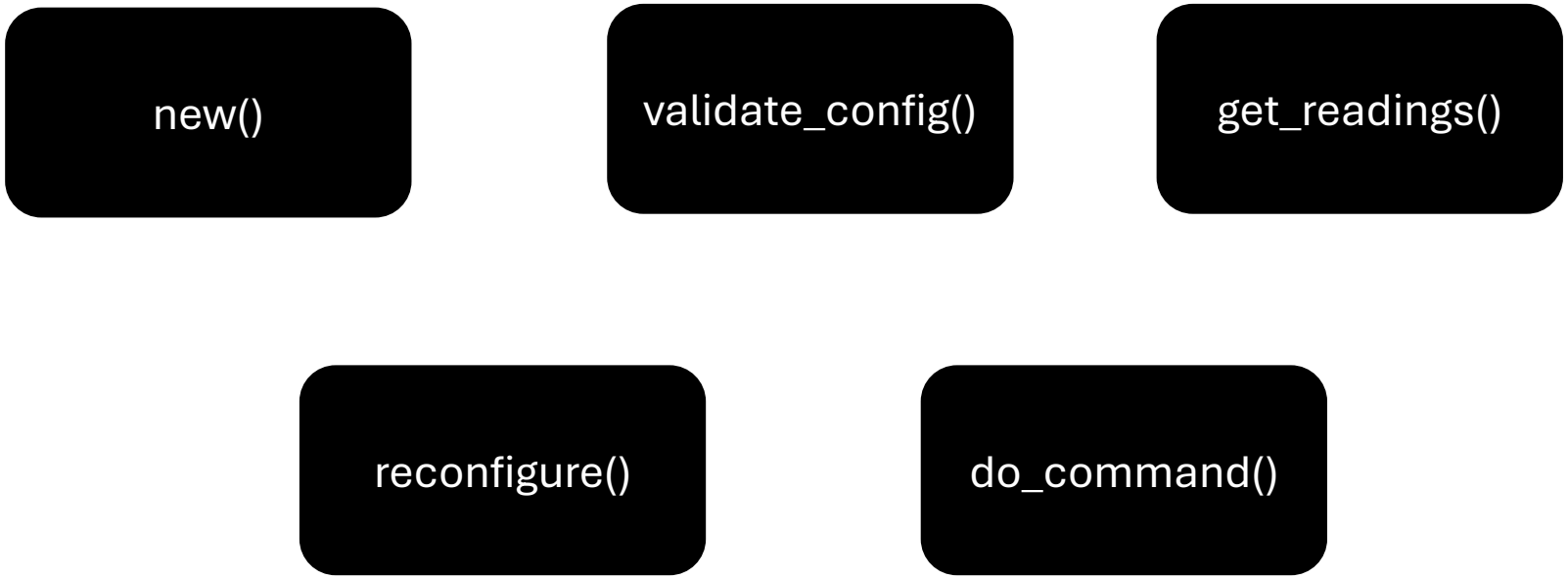
- The model points to the Pdetect class in pdetect.py.
  - When a resource is created (e.g., sensor-1 in the Viam UI), Viam uses the model triplet to instantiate this model.

- pdetect.py:
  - Queries the Vision Service (like myPeopleDetector) to detect people via camera feed.
  - Returns person_detected = 1 or 0.

- The Viam App shows live logs and values via the UI, helping me debug and monitor sensor results.

Task 3: Modular Registry: Module Implementation

Goal: Add custom logic to Pdetect class (**pdetect.py**) to execute the goals of Task 3. Following the docs & looking at the ‘simple-module’ example in the Viam Python SDK, I had to make sure I edited the following within Pdetect:



Task 3: Modular Registry: Implement the Component API

new():

- This method is responsible for creating and returning a new instance of the Pdetect sensor class.
  - It receives the config and dependencies from the Viam system.
  - It initializes the sensor (`sensor = cls(config.name)`) and then immediately calls `reconfigure()` to apply the configuration and wire up dependencies.
  - It returns the fully ready-to-use sensor instance.

```python
@classmethod
def new(
    cls, config: ComponentConfig, dependencies: Mapping[ResourceName, ResourceBase]
) -> Self:
    """
    Instantiate a new Pdetect sensor instance and configure it with the given settings.

    Args:
        config (ComponentConfig): The configuration for this sensor
        dependencies (Mapping[ResourceName, ResourceBase]): The dependencies (both implicit and explicit)

    Returns:
        Self: A fully initialized instance of the Pdetect sensor.
    """
    sensor = cls(config.name)
    sensor.reconfigure(config, dependencies)
    return sensor
```

Task 3: Modular Registry: Implement the Component API

reconfigure():

- Triggered when the component's configuration is updated in the Viam app
  - Reads the latest `camera_name` value from the incoming `config` object
  - Validates that the required `camera_name` attribute exists
  - Retrieves the required dependency `myPeopleDetector` from the dependency map (throws error if not available)
  - Casts that dependency as a `VisionClient` for person detection
  - Stores both `camera_name` and vision client internally for use in detection logic
  - Calls the base class implementation (`super().reconfigure(...)`) to ensure any built-in updates are applied

```python
def reconfigure(
    self, config: ComponentConfig, dependencies: Mapping[ResourceName, ResourceBase]
):
    """This method allows you to dynamically update your service when it receives a new `config` object.

    Args:
        config (ComponentConfig): The new configuration
        dependencies (Mapping[ResourceName, ResourceBase]): Any dependencies (both implicit and explicit)
    """
    if not config.attributes or "camera_name" not in config.attributes.fields:
        raise ValueError("Missing required attribute: camera_name")

    self.camera_name = str(config.attributes.fields["camera_name"].string_value)

    vision_resource = dependencies.get(Vision.get_resource_name("myPeopleDetector"))
    if not vision_resource:
        raise ValueError("Required dependency 'myPeopleDetector' not found")

    self.vision = vision_resource
    return super().reconfigure(config, dependencies)
```

Task 3: Modular Registry: Implement the Component API

validate_config():

- Ensures that the user-supplied configuration is valid before the module is started.
  - Checks if the required "camera_name" attribute is present.
  - If it's missing, it raises an error so the module doesn't run with invalid settings.
- Declares required and optional dependencies for the module.
  - Dependencies returned: required: "myPeopleDetector"
  - This tells Viam to pass in the Vision service resource with this name at runtime.

```python
def validate_config(
    cls, config: ComponentConfig
) -> Tuple[Sequence[str], Sequence[str]]:
    """
    This method allows you to validate the configuration object received from the machine,
    as well as to return any required dependencies or optional dependencies based on that `config`.

    Args:
        config (ComponentConfig): The configuration for this resource

    Returns:
        Tuple[Sequence[str], Sequence[str]]: A tuple where the
            first element is a list of required dependencies (myPeopleDetector) and the
            second element is a list of optional dependencies (empty in this case)
    """
    if "camera_name" not in config.attributes.fields:
        raise Exception("Missing required attribute: camera_name")
    return ["myPeopleDetector"], []
```

Task 3: Modular Registry: Implement the Component API

do_command():

- Allows the sensor to query the `myPeopleDetector` vision service and returns `person_detected: 1` if a person is seen with >0.5 confidence, otherwise 0.

```python
async def do_command(
    self,
    command: Mapping[str, ValueTypes],
    *,
    timeout: Optional[float] = None,
    **kwargs
) -> Mapping[str, ValueTypes]:
    """
    Execute a custom command to check for the presence of a person using the vision service.

    This method queries the configured vision service (`myPeopleDetector`) for object
    detections from the specified camera. If any detection is classified as a "person"
    with a confidence greater than 0.5, the method returns a result indicating a person
    was detected. Otherwise, it indicates no person was found.

    Args:
        command (Mapping[str, ValueTypes]): A dictionary of command arguments.
            This implementation does not use any input arguments.
        timeout (Optional[float]): An optional timeout in seconds for the operation.
        **kwargs: Additional optional keyword arguments.

    Returns:
        Mapping[str, ValueTypes]: A dictionary with a single key `"person_detected"`:
            - 1 if a person is detected
            - 0 if no person is detected
    """
    detections = await self.vision.get_detections_from_camera(self.camera_name)
    for d in detections:
        if d.class_name.lower() == "person" and d.confidence > 0.5:
            return {"person_detected": 1}
    return {"person_detected": 0}
```

Task 3: Modular Registry: Implement the Component API

- get_readings():
  - sensor interface that Viam calls to retrieve the latest data from the sensor.
  - Invokes the internal do_command() method to perform the actual person detection logic.
- Wraps the result from do_command() in a dictionary with a consistent sensor reading key:
  - Returns: { "person_detected": 1 } if a person is detected, Returns: { "person_detected": 0 } if no person is detected.

- This method ensures compatibility with the Viam Sensor API, allowing the module to be used like any other built-in Viam sensor.

```python
async def get_readings(
    self,
    *,
    extra: Optional[Mapping[str, Any]] = None,
    timeout: Optional[float] = None,
    **kwargs
) -> Mapping[str, int]:
    """
    Retrieve the latest reading from the person detection sensor.

    This method queries the associated vision service to check whether a person
    is currently detected in the video feed from the configured camera. It returns
    a dictionary containing a single reading: 1 if a person is detected, 0 otherwise.

    Args:
        extra (Optional[Mapping[str, Any]]): Additional metadata or parameters
            passed to the sensor (not used in this implementation).
        timeout (Optional[float]): Timeout in seconds for the operation, if applicable.
        **kwargs: Additional keyword arguments passed to the method (unused).

    Returns:
        Mapping[str, int]: A dictionary with the key `"person_detected"`
        mapped to an integer with a value of 1 (detected) or 0 (not detected).
    """
    result = await self.do_command({})
    return {"person_detected": int(result["person_detected"])}
```

Task 3: Modular Registry: Implement the Component API

- main.py:
  - Uses Viam's registry to register the pdetect model under the Sensor API, linking the model name (`dl-org:sensor-pd:pdetect`) to my Pdetect implementation.
  - Includes error handling to avoid duplicate registration when hot reloading.
  - Attaches the registered model to the module so it can be discovered and used by the Viam RDK.
  - Initializes and launches the module to connect with the Viam cloud, enabling remote control and configuration.

sensor-pd > src > main.py > ...

```python
import asyncio
from viam.module.module import Module
from viam.resource.registry import Registry, ResourceCreatorRegistration
from viam.components.sensor import Sensor
from viam.errors import DuplicateResourceError

try:
    from models.pdetect import Pdetect
except ModuleNotFoundError:
    # when running as local module with run.sh
    from .models.pdetect import Pdetect

async def main():
    """
    Register the custom sensor model and start the module.

    This function registers the `Pdetect` sensor model with the Viam resource registry
    and initializes a `Module` instance using command-line arguments. It handles
    duplicate registration errors, then starts the module to serve
    the registered model.
    """
    try:
        Registry.register_resource_creator(Sensor.API, Pdetect.MODEL, ResourceCreatorRegistration(Pdetect.new, Pdetect.validate_config))
    except DuplicateResourceError:
        pass

    module = Module.from_args()
    module.add_model_from_registry(Sensor.API, Pdetect.MODEL)
    await module.start()

if __name__ == '__main__':
    asyncio.run(main())
```

Task 3: Modular Registry: Local Testing

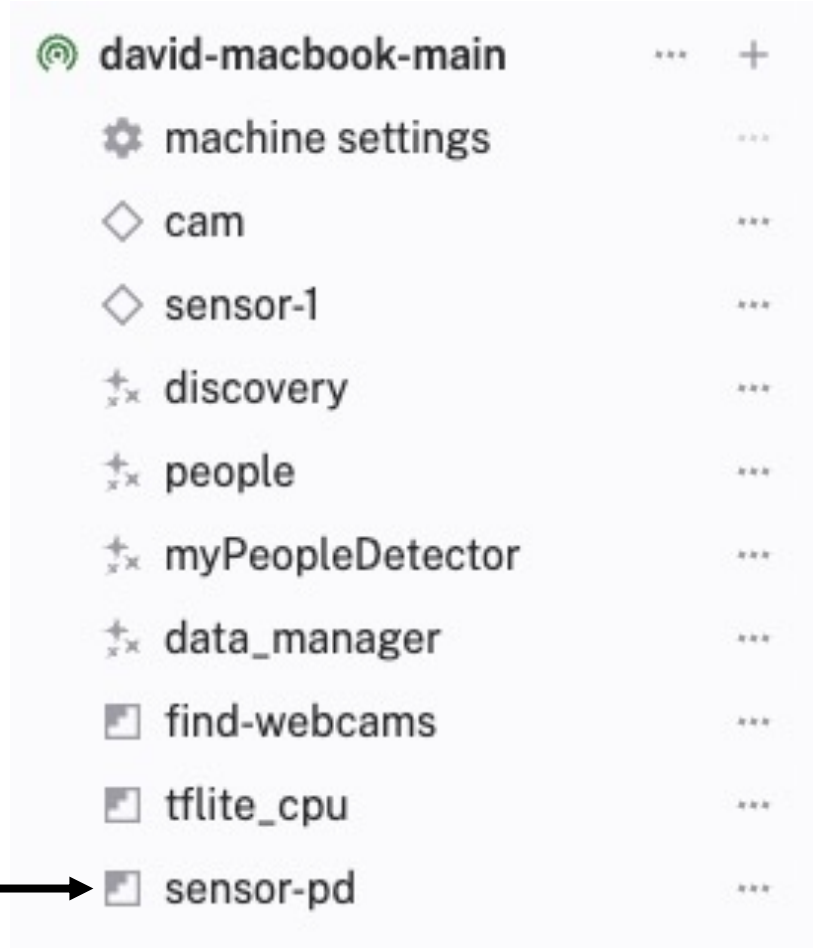
Goal: Test my custom module locally.

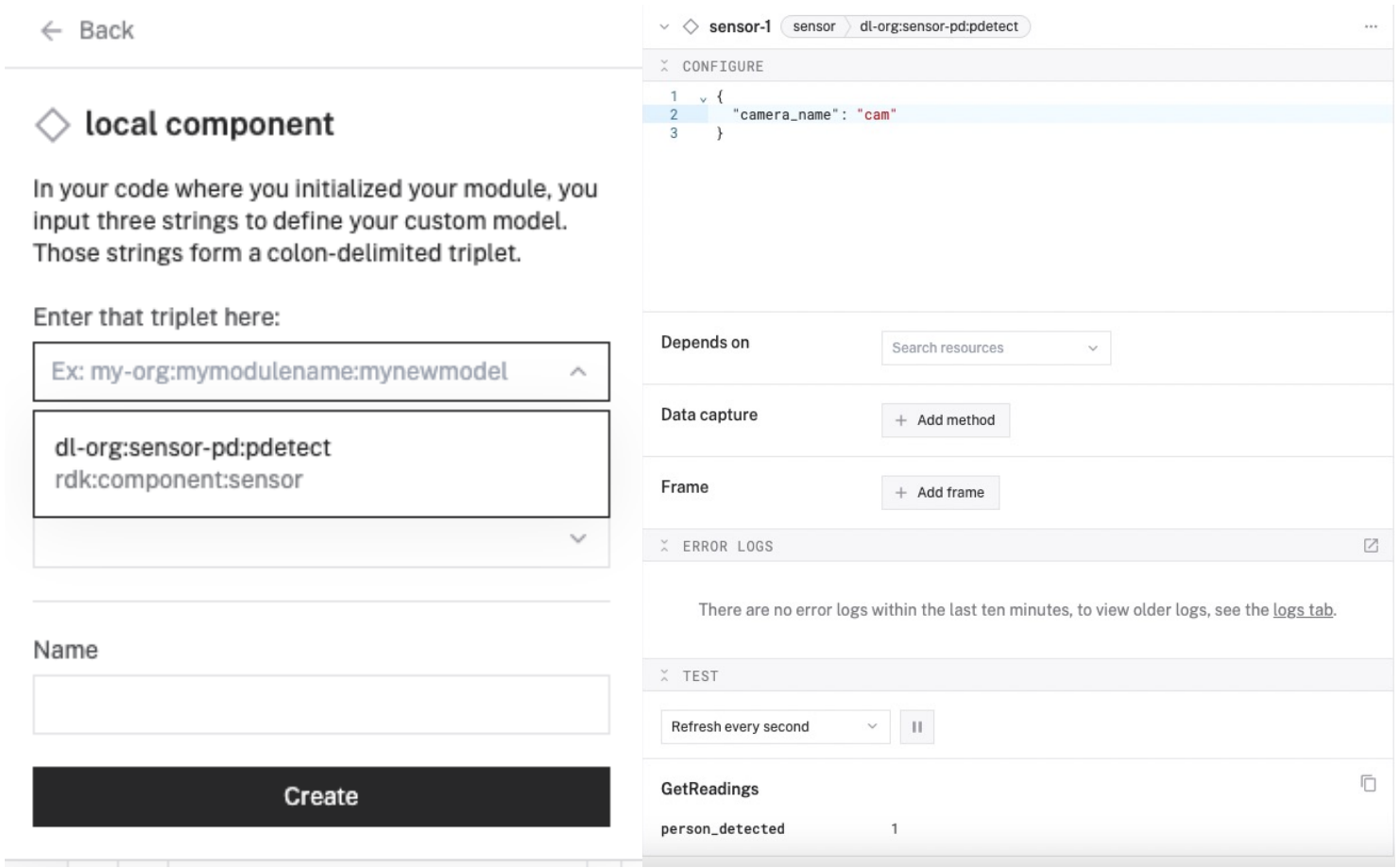
```
Module successfully generated at sensor-pd
(base) davidlevine@Davids-Air-3 ~ % cd Desktop/viam-interview-project/sensor-pd
(base) davidlevine@Davids-Air-3 sensor-pd % chmod 755 reload.sh
(base) davidlevine@Davids-Air-3 sensor-pd % sh setup.sh
Virtualenv found/created. Installing/upgrading Python packages...
(base) davidlevine@Davids-Air-3 sensor-pd % viam module reload --local --part-id accf7c3d-370b-4268-a869-70d878f3e6
1a
Info: Starting build
Info: Starting setup step: "./setup.sh"
Virtualenv found/created. Installing/upgrading Python packages...
Info: Starting build step: "rm -f module.tar.gz && tar czf module.tar.gz requirements.txt src/*.py src/models/*.py
meta.json setup.sh reload.sh"
Info: Completed build
Info: Reload complete
(base) davidlevine@Davids-Air-3 sensor-pd %
```

Steps to configure my local module on my machine

Task 3: Modular Registry: Adding & Testing the Sensor Component

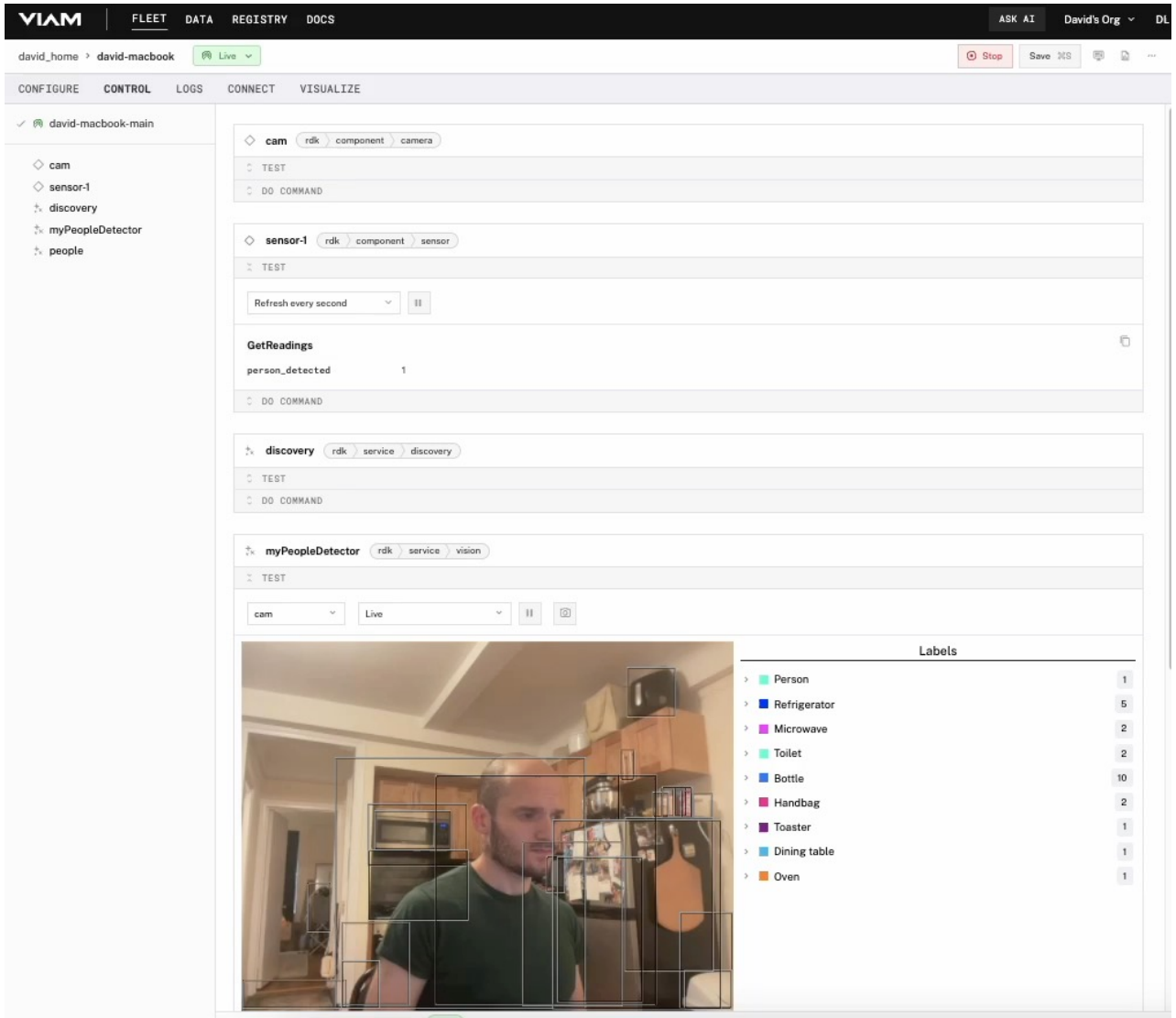
Goal: Add my custom sensor component in the Viam UI.





Task 3: Modular Registry: Adding & Testing the Sensor Component

Goal: Test my custom sensor component in the Viam UI.



Task 3: Modular Registry: Error Handling

Goal: Find errors and fix bugs to complete Task 3.

- Errors: `DuplicateResourceError: Cannot add resource with duplicate name "rdk:component:sensor/dl-org:sensor-pd:pdetect”` → caused registration error (below)
  - Cause:
    - The module attempted to register the same resource more than once during hot reloads.
  - Fix (**main.py**):
    - Wrapped the registration line in a try/except block to catch and suppress the DuplicateResourceError.

```
5/28/2025, 10:10:08 AM error
rdk.resource_manager.rdk:component:sensor/sensor-1
resource/graph_node.go:297   resource build error: unknown
resource type: API "rdk:component:sensor" with model "dl-
org:sensor-pd:pdetect" not registered   resource
rdk:component:sensor/sensor-1  model dl-org:sensor-pd:pdetect
```

Registration error caused by duplicate registration

Before fix:

```
Registry.register_resource_creator(Sensor.API, Pdetect.MODEL, ResourceCreatorRegistration(Pdetect.new, Pdetect.validate_config))
```

After fix:

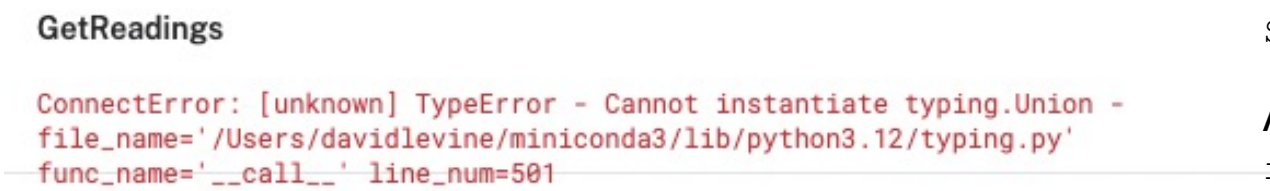
```
try:
    Registry.register_resource_creator(Sensor.API, Pdetect.MODEL, ResourceCreatorRegistration(Pdetect.new, Pdetect.validate_config))
except DuplicateResourceError:
    pass
```

try/except block to catch and suppress the DuplicateResourceError

Task 3: Modular Registry: Error Handling

Goal: Find errors and fix bugs to complete Task 3.

- Error: `TypeError – Cannot instantiate typing.Union`
  - Cause:
    - Attempted to wrap a basic type (`int`) inside `SensorReading`, which isn't necessary and led to incompatible typing. (SensorReading is a type alias)
  - Fix (**pdetect.py → get_readings()** method):
    - Removed the use of `SensorReading()` and returned a plain `int` instead.



Type Error found in sensor_1 log

Before fix:

```
return {"person_detected":
SensorReading(int(result["person_detected"]))}
```

After fix:

```
return {"person_detected":
int(result["person_detected"])}
```

Removed the use of `SensorReading()`

Next Steps: Upload Module to Viam Registry

1. Set your module to public or private visibility.
When running `viam module generate`, choose whether others can access the module.

2. Update meta.json.
Ensure the entrypoint, build, path, and supported arch values are set correctly.
This file tells Viam how to build, package, and run the module.

3. Package your module.
Run the build command (or use build.sh) to create a module.tar.gz file.

4. Login to Viam.

5. Register your module.

6. Upload your module.
Push the module to the registry.

7. Use the module in the cloud.

Opportunities for Improvement

- Customizable Configuration via Viam UI
  - Support configurable confidence thresholds, detection classes, and different camera inputs.
- Capture & Store Data with Viam
  - Extend to support other ML models beyond people detection in the Vision service.
  - Integrate with Viam's Data Capture UI to view and download results.
- Build a UI for Sensor Control
  - Develop a lightweight frontend to:
    - Display live detection results from `get_readings`.
    - Visualize logs and sensor state.
- Robust Error Handling
  - Add better exception management, validation, and user-visible error messages.
- Developer Experience & Docs
  - Publish module to Viam Registry.
  - Include links to my GitHub, Docs, and example `meta.json` in the Registry.