GStreamer for Machine Vision & Beyond

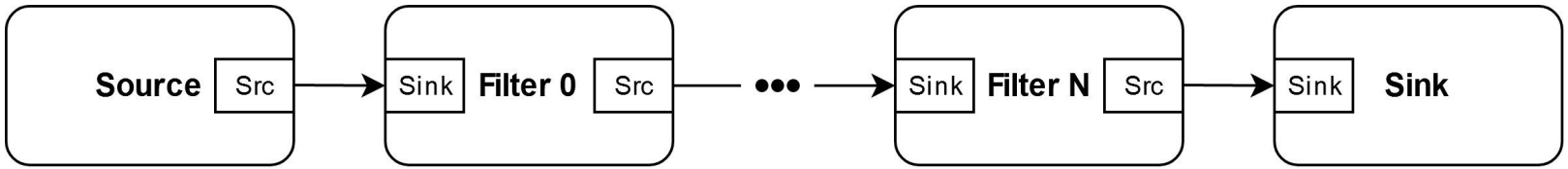
https://github.com/BrianOfrim/gstreamer-pyspin-src

What is GStreamer?

An open source framework for constructing multimedia pipelines

Pipelines consist of connected elements of 3 basic types:

- **Sources**: Elements that **produce** data
  - cameras, microphones, media files, network
- **Filters**: Elements that **manipulate** data
  - compression, transcoders, re-formaters, overlay, augmentations, processing
- **Sinks**: Elements that **consume** data
  - display, files, network stream, real time processing applications



Example Video Pipeline

$ gst-launch-1.0 pyspinsrc ! videoconvert ! xvimagesink sync=false

pyspinsrc - produces images from Spinnaker compatible cameras

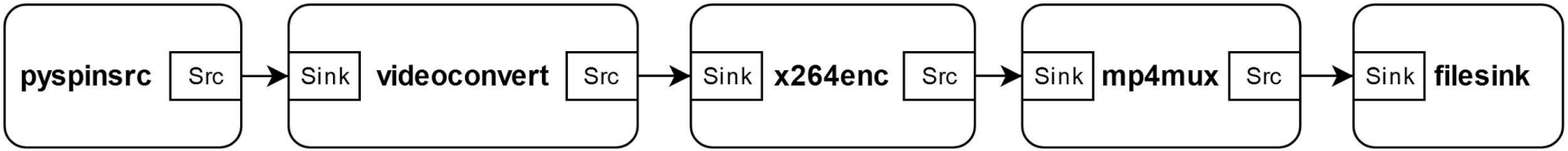
videoconvert - ensures data from pyspinsrc can be consumed by xvimagesink

xvimagesink - displays the images

Compression

Sample Compression Pipeline

$ gst-launch-1.0 pyspinsrc ! videoconvert ! x264enc ! mp4mux ! filesink location="pyspinsrc_xh264.mp4"



x264enc - encodes raw video into H.264 compressed data

mp4mux - merges audio and video streams into .mp4 file format

filesink - writes incoming data into a local file

Hardware Compression Plug-ins

Fully and easily utilize available hardware resources

Due to the popularity of multimedia applications, most devices have dedicated hardware for encoding (compressing) and decoding (decompressing) video streams.

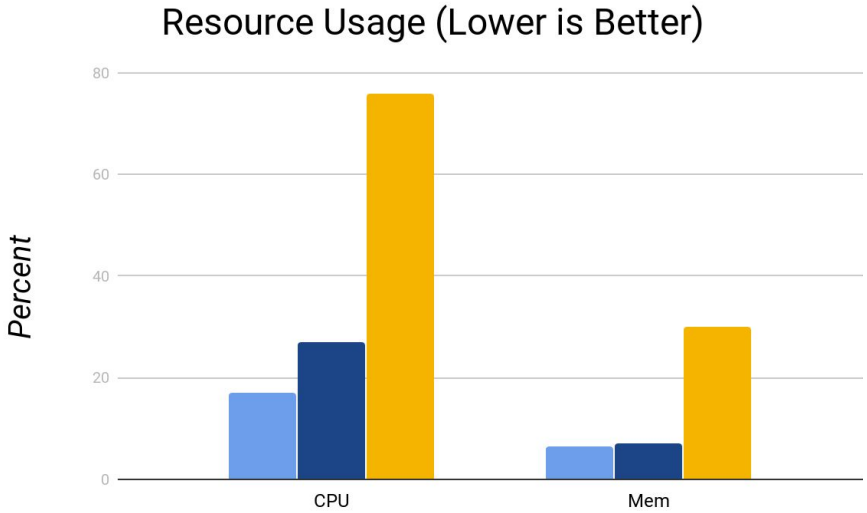
This hardware can help to:

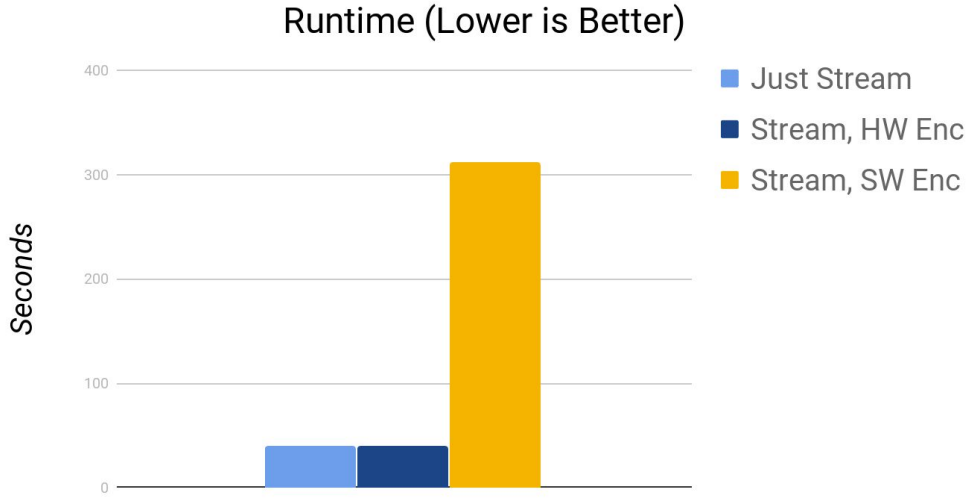
- **accelerate** encoding/decoding
- **free up the cpu** for other tasks
- **improve energy efficiency** when compared to software implementations

Nvidia Linux for Tegra

Nvidia hardware accelerated video encoding (compression)

H.264 encoding benchmark: BFS-U3-31S4C-C, 2048x1536, BGRA, 25fps = ~314MB/s



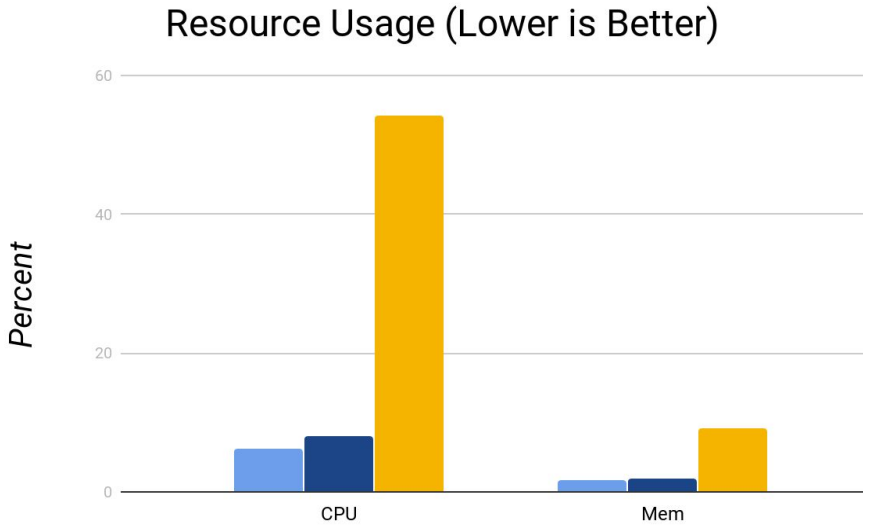


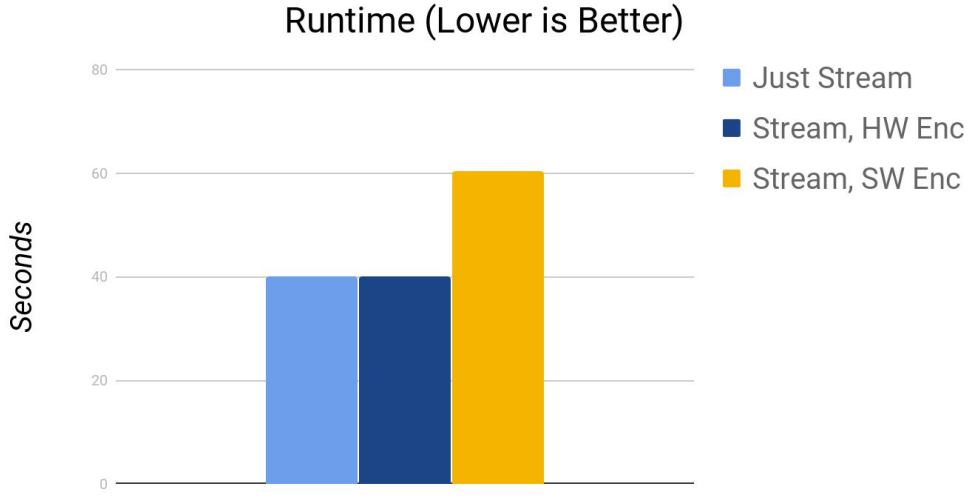
Intel Graphics - VAAPI

Intel hardware accelerated video encoding (compression)

H.264 encoding benchmark: BFS-U3-31S4C-C, 2048x1536, BGRA, 25fps = ~314MB/s

Computer: Intel i5-8350U CPU @ 1.70GHz, UHD Graphics 620





Network Live Streaming

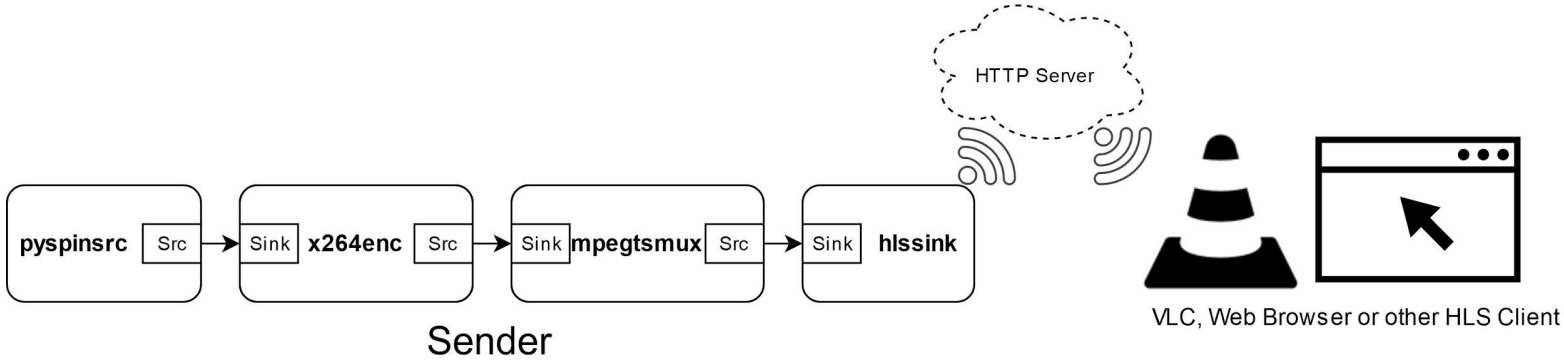
HLS (HTTP Live Streaming)

Most useful for compatibility, versatility, and quality at the expense of latency

Sender uploads short video file segments to a server

Receiver downloads these segments from the server and plays them back

Example application: Broadcasting over the internet to many types of devices

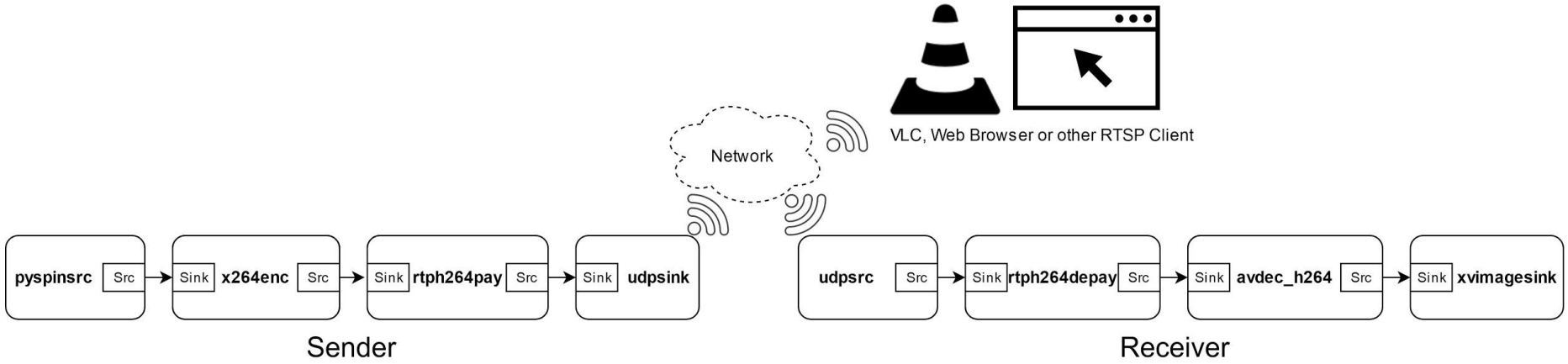


RTP/RTSP (Real-time Transport Protocol)

Most useful for streaming data with minimal latency on a local network

Can be configured to do a 1 (sender) to N (receivers) multicast

Example applications: Streaming video over an ad-hoc network from a robot

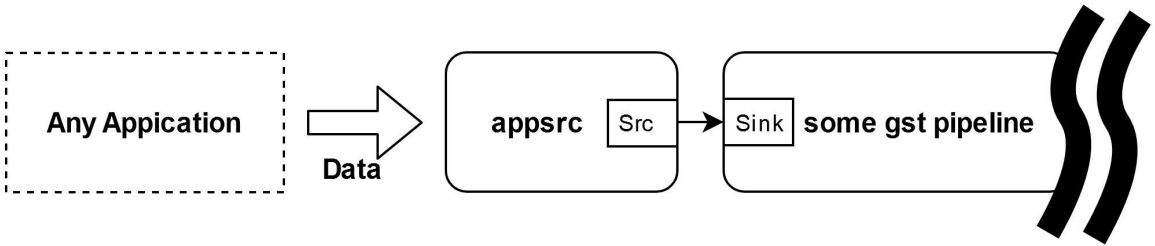


Integrating with Applications

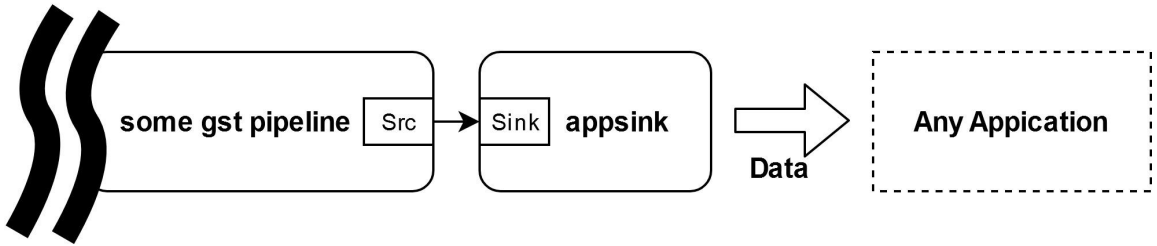
Appsrc / Appsink

GStreamer has plug-ins that allow for any application to act as a source or sink

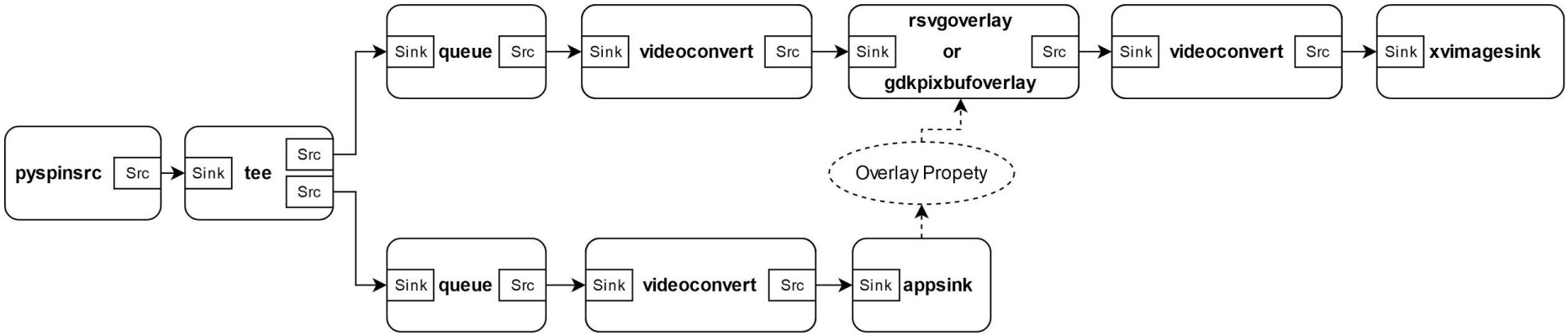
appsrc - allows an application to feed data buffers to a pipeline



appsink - allows an application to receive data buffers from a pipeline



Example Image Processing and Overlay Pipeline



tee - splits data to multiple pads

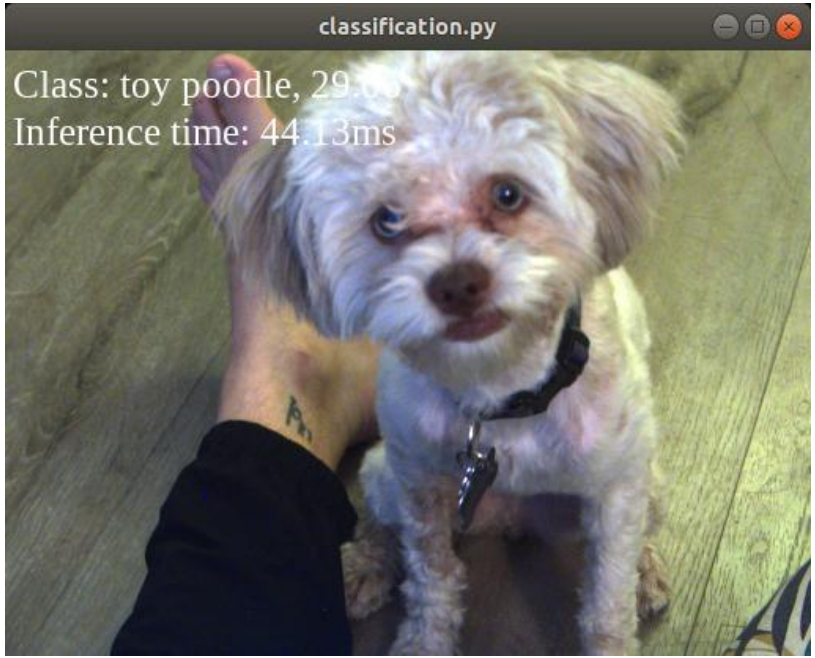
queue - data queue

rsvgoverlay - overlays SVG graphics over the video stream

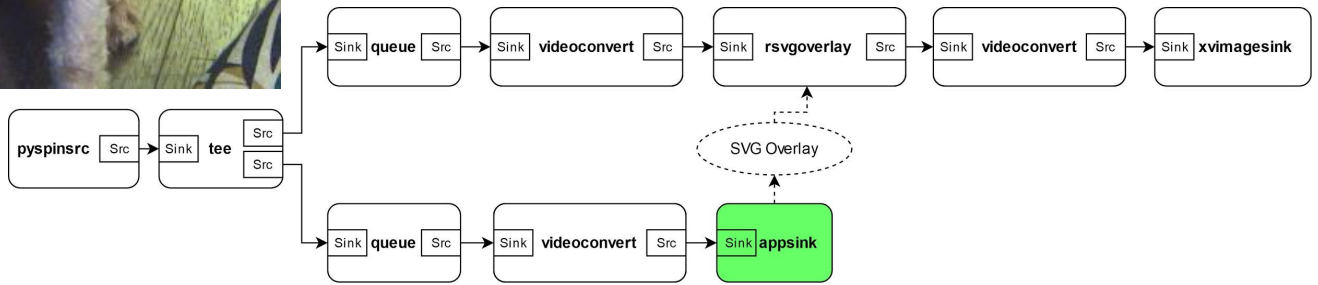
gdkpixbufoverlay - overlays an image on the video stream

appsink - allows an application, in this case python, to access image data buffers

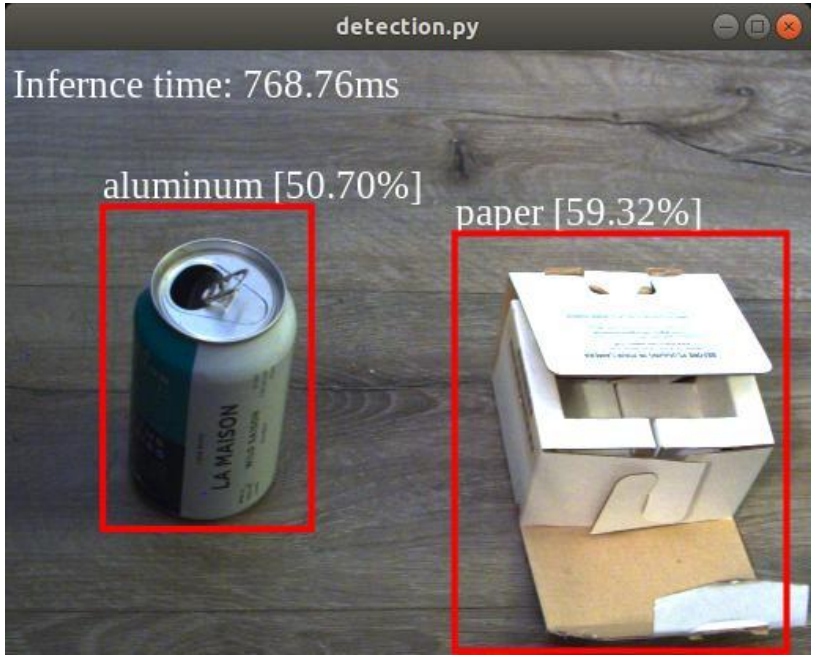
Appsink Example: Classification



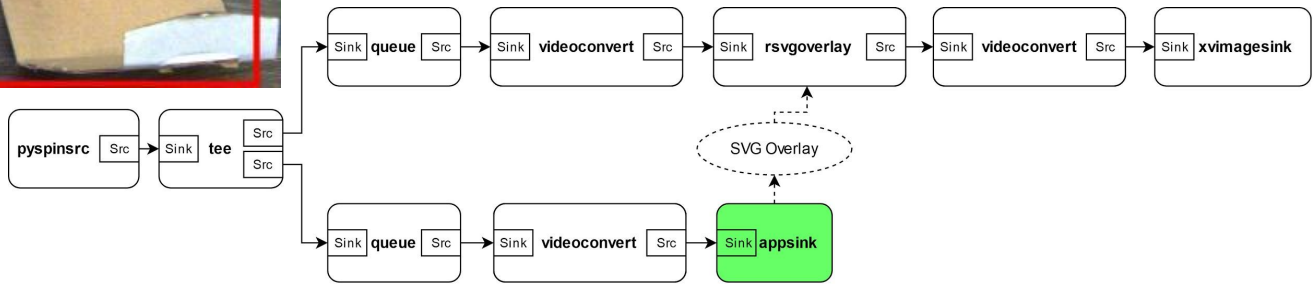
Pre-trained mobilenet_v2 classifier from: https://github.com/pytorch/vision/blob/master/torchvision/models/mobilenet.py



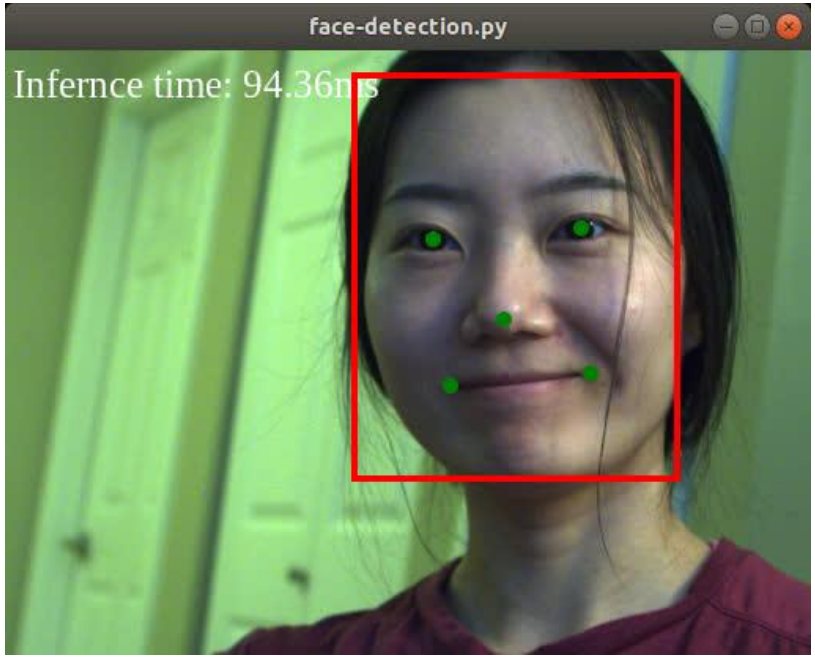
Appsink Example: Recycling Detection



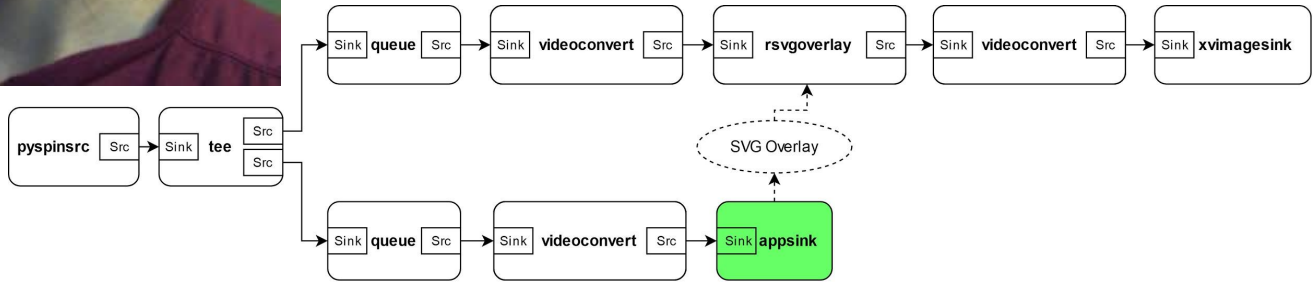
Recycling detection trained via the Boja process:
https://github.com/BrianOfrim/boja



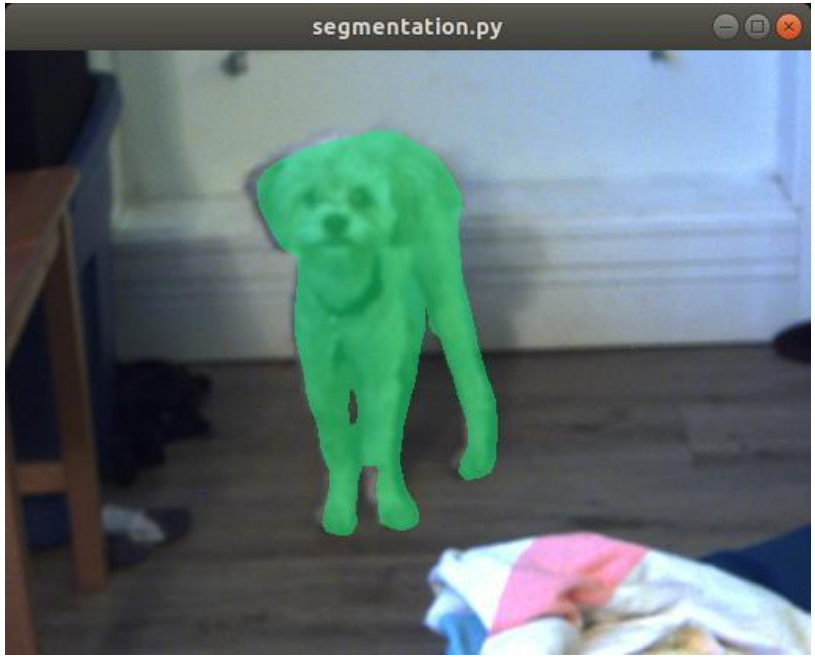
Appsink Example: Face Detection



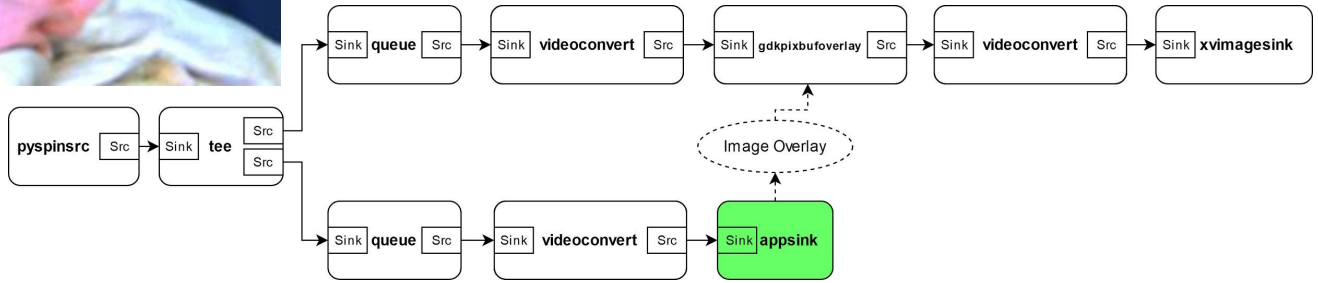
Face Detection model from:
https://github.com/timesler/facenet-pytorch



Appsink Example: Segmentation

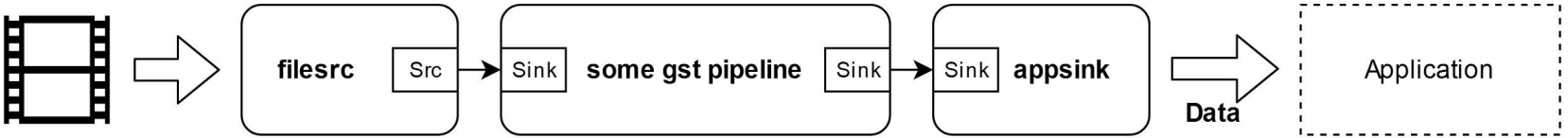


Pretrained segmentation model from: https://github.com/pytorch/vision/tree/master/torchvision/models/segmentation

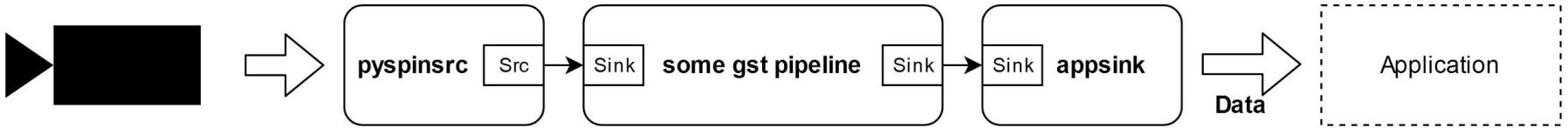


Faster and Easier Application Development

Stream from a video to help with development and testing



Stream from a camera for deployment

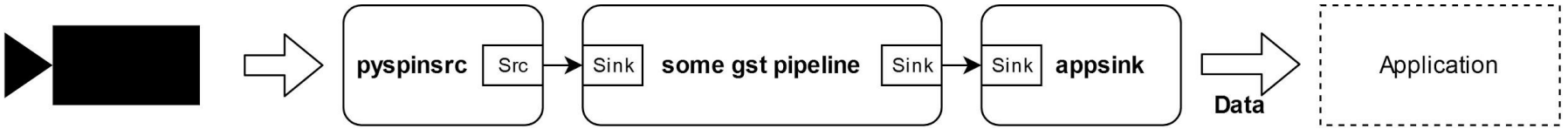


Deploy Application on the Edge or a Server

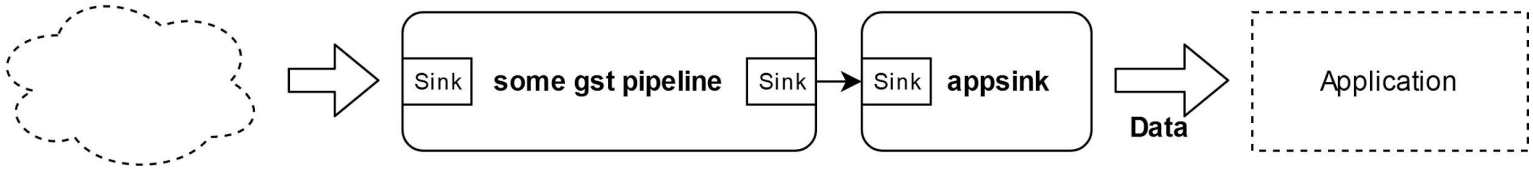
Application does not need to know or care where the image stream is coming from

Image source can be a local camera or a real time network video stream

Edge:



Server:



Focus on Image Processing

Shouldn’t need to reinvent the wheel with custom image acquisition code to receive a simple image stream

Can use a pre-made high performance image acquisition plug-in and focus on the image processing application