

Computer Vision in *FIRST*

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Agenda

- Overview
- Cameras
- Processing Hardware
- Image Processing Software
 - Programming
 - Interactive

Overview

- What is computer vision?
- Photography + Computer Processing
- Start with good photos
 - Exposure & lighting
 - Composition & focal length
- Then process digitized values to measure, compare, and rate

Overview

- Math ... not magic
- Example – What makes the target unique?
- Describe it to a friend on the phone/email
- Quantify that info by measuring
 - Color, size, area/CH-Area,
 - Aspect Ratio, Moment of Inertia
 - Limit Tests
- FRC Workflow



Cameras

IP \$\$



USB Webcam \$



Cell phone \$\$\$



USB 3.0 industrial \$\$\$



Pixy Cam \$



IP Cameras

- Typically used for security
- Axis has low latency and good API. Others ???
- Support multiple clients
- Easiest to stream to web page or other viewers
- Fixed lens, basic configuration

USB Web Cameras

- Used for chat/video conference
- Price and quality range is HUGE
 - HD? 4K? \$30 to \$40 seems sufficient
- SW support on linux is via UVC
- Mounting issues
- Fixed lens

Cell Phone Cameras

- Used for selfies, ..., and robots
- Write an app
- Integrated image processor
- SW support and documentation are good
- How to mount on robot
- Lens adapters available

PixieCam

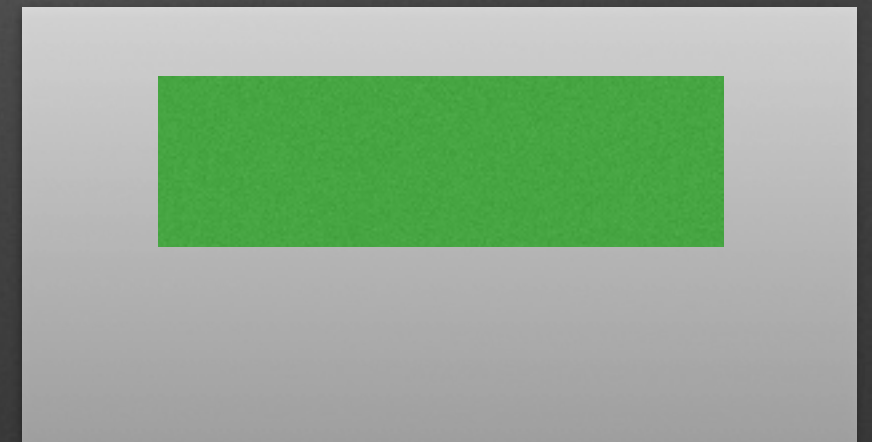
- Camera with built-in processor
- Limited capabilities, but has been used successfully by some teams this year (blob and color code tracking)
- Lots of output types (SPI, I2C, UART, analog/digital)
- Very fast - 50 updates/sec

USB3 Industrial Cameras

- Used for machine vision – visual inspection
- Basler Dart and Point Grey Chameleon3 have recently become FRC-priced
- Operate at USB2 speeds on roboRIO
- SW support and documentation are excellent – GenICam
- 12mm S or CS lens/filter system
- Rich configuration, high performance

Basler Dart

- Sensitive sensor & Global Shutter
- 54fps color, 120 BW (USB3 full frame)
- Area scan – lower bw, even higher fps
- Hundreds of properties
- Digital lines for exposure control
- Lenses from companies like Edmunds



Hardware processing

- RoboRIO – in an independent thread
- Independent HW
 - Driver station computer
 - Onboard coprocessor
 - Raspberry PI, Kangaroo, nVidia TK1, etc.

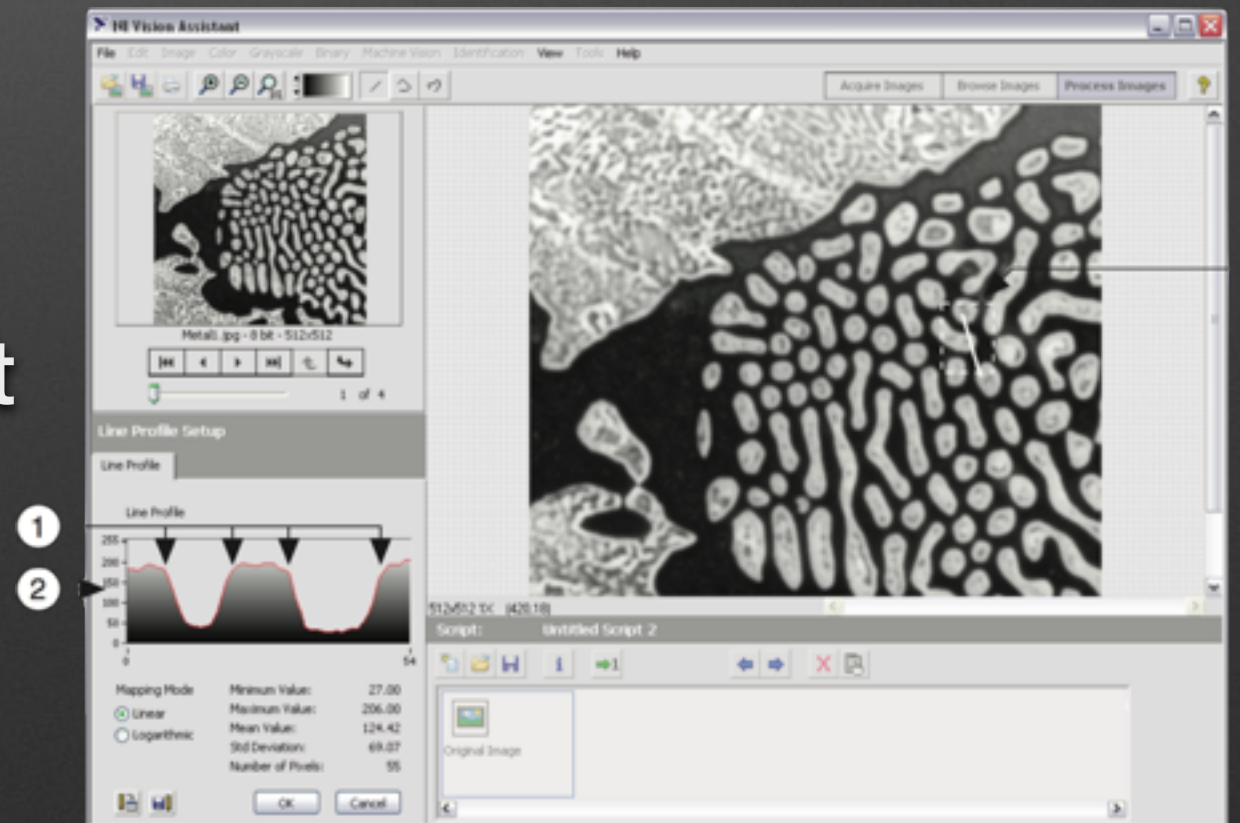


OpenCV

- Popular computer vision library
- C, C#, C++, Java, Python, and LabVIEW interfaces
- Runs on Linux, Windows, Mac, iOS, and Android
- Designed for computational efficiency and can take advantage of accelerated hardware
- User community of 47,000 people and over 9M downloads

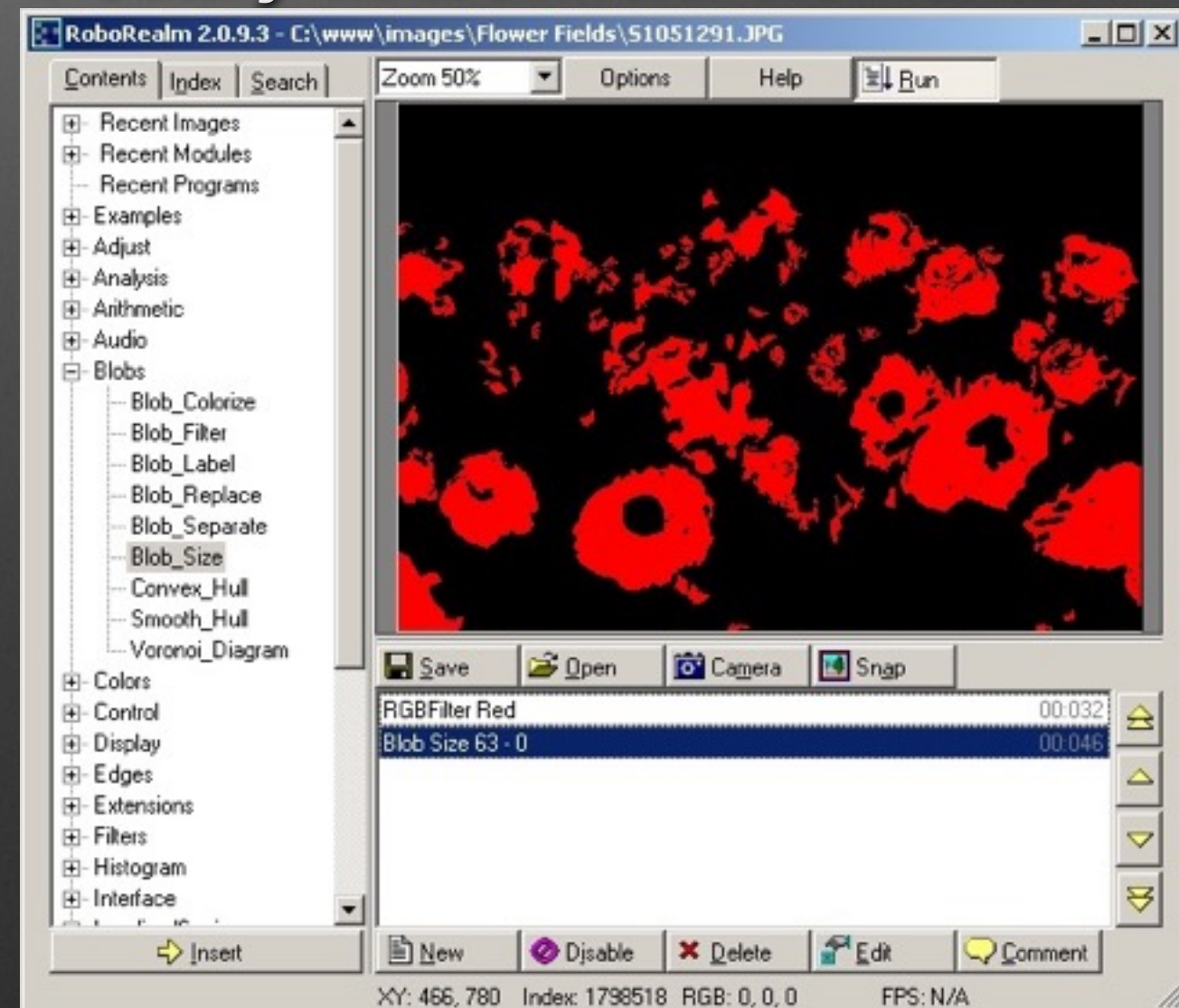
NI Vision VDM, IMAQdx

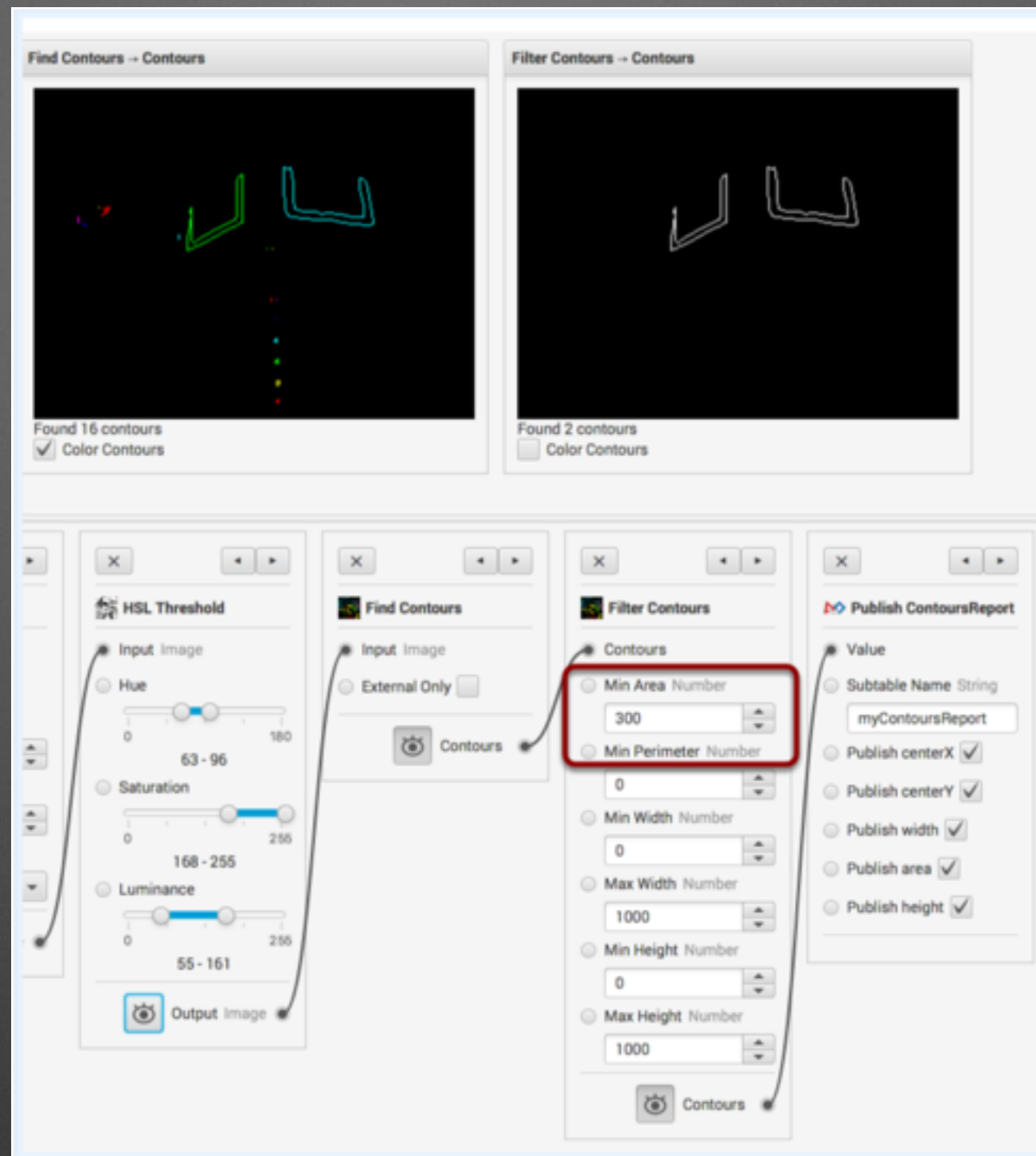
- C, .NET, and LabVIEW API
- High performance machine inspection, defect ID
- Vision Assistant is great for exploration, then codegen
- Windows, roboRIO, FPGA
- Utilities speed development



RoboRealm

- RoboRealm is a software application that provides you the ability to rapidly process images from the Kinect and/or Axis IP camera in order to visually detect field elements
- Runs on Windows PC



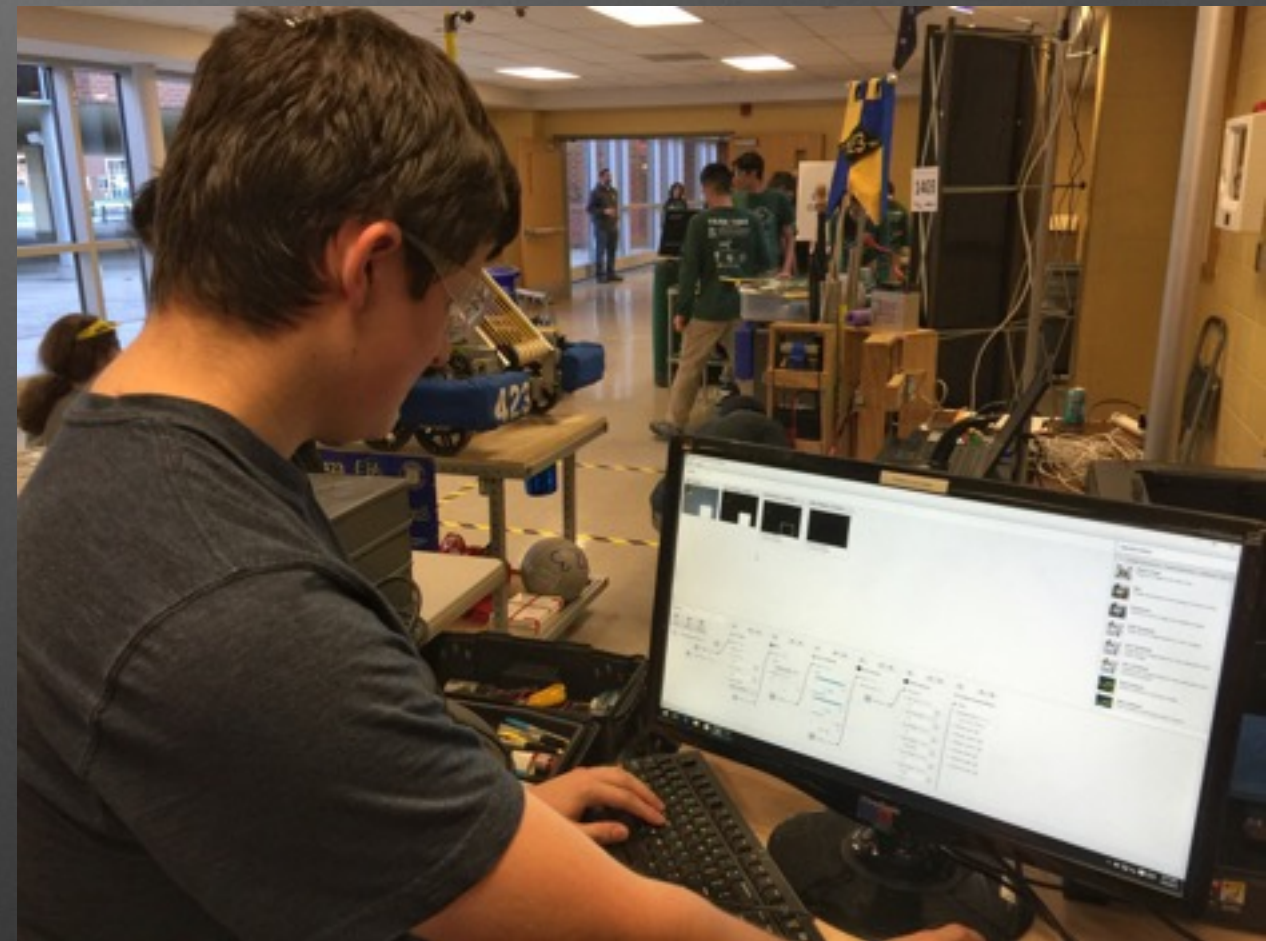


GRIP

Graphically Represented Image Processing

GRIP

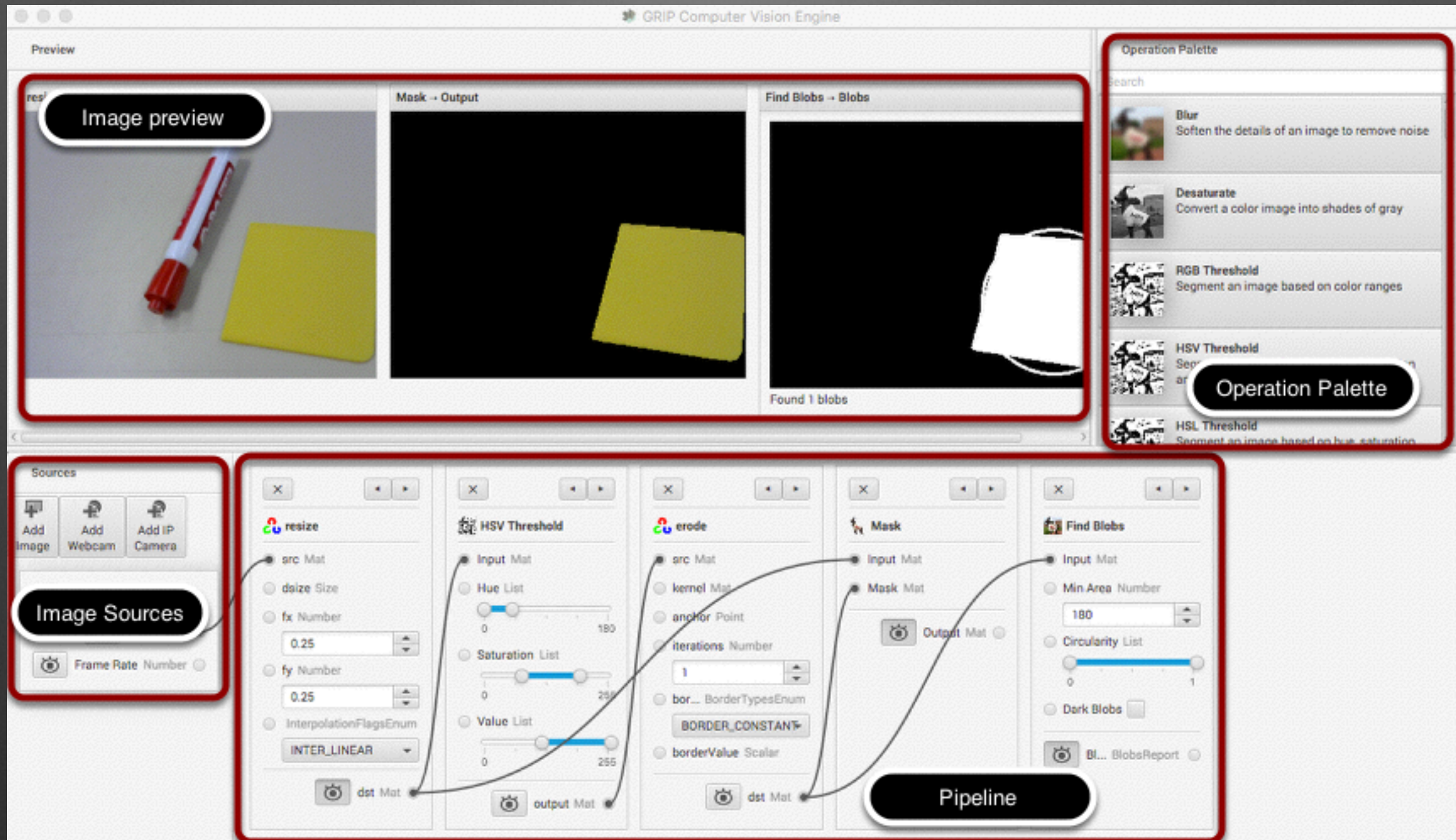
- Developed as a WPI RBE/CS senior capstone project
- Designed to make vision processing easier
 - FRC teams and researchers
- Based on OpenCV
- Works equally well with any robot programming language



GRIP Workflow

- Select a source - camera, video, or saved images
- Create the processing pipeline while viewing intermediate results
- Set outputs via network tables variables
- Robot program gets values and drives/turns/aims at target

Grip User Interface

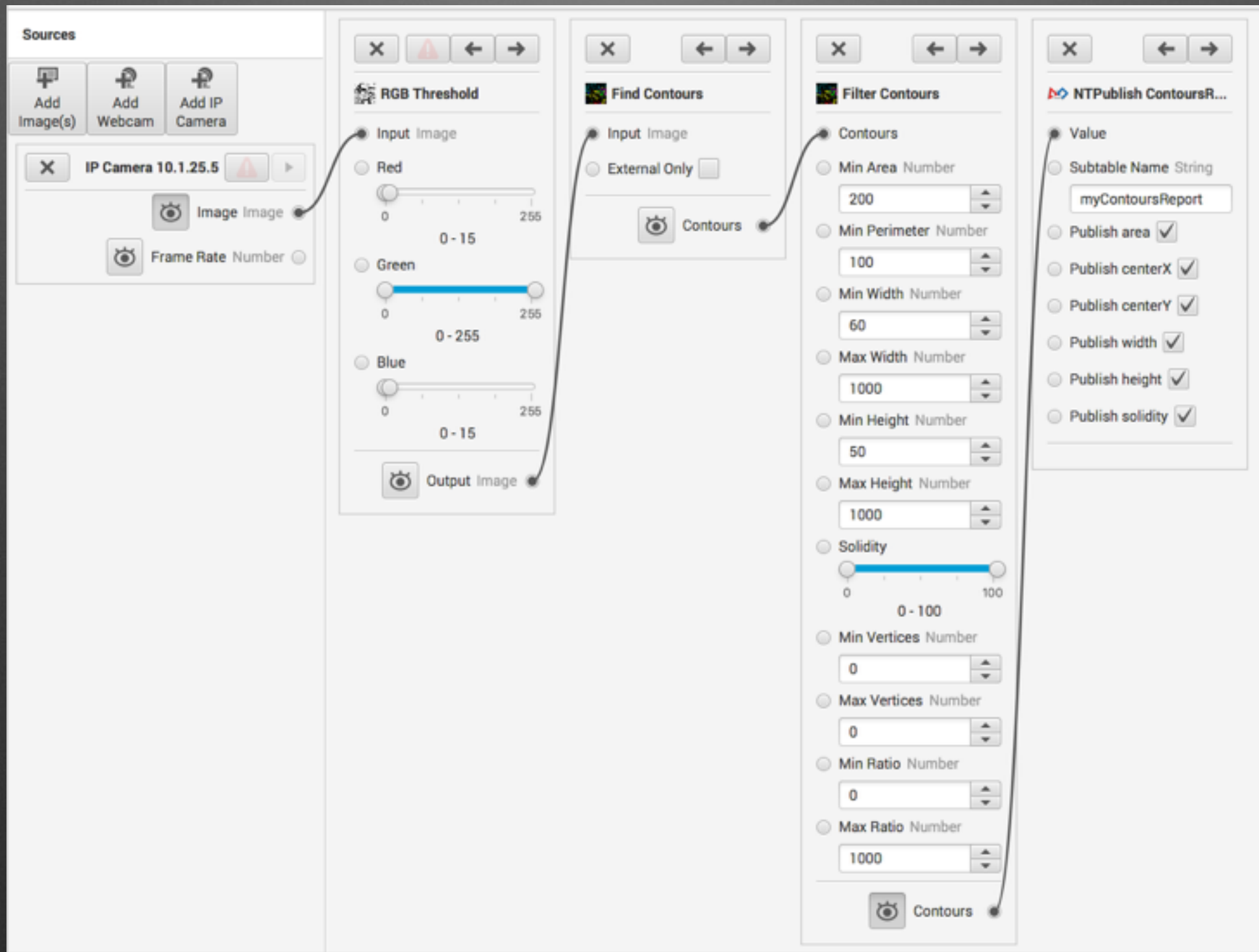


FRC 125 the Neutrons

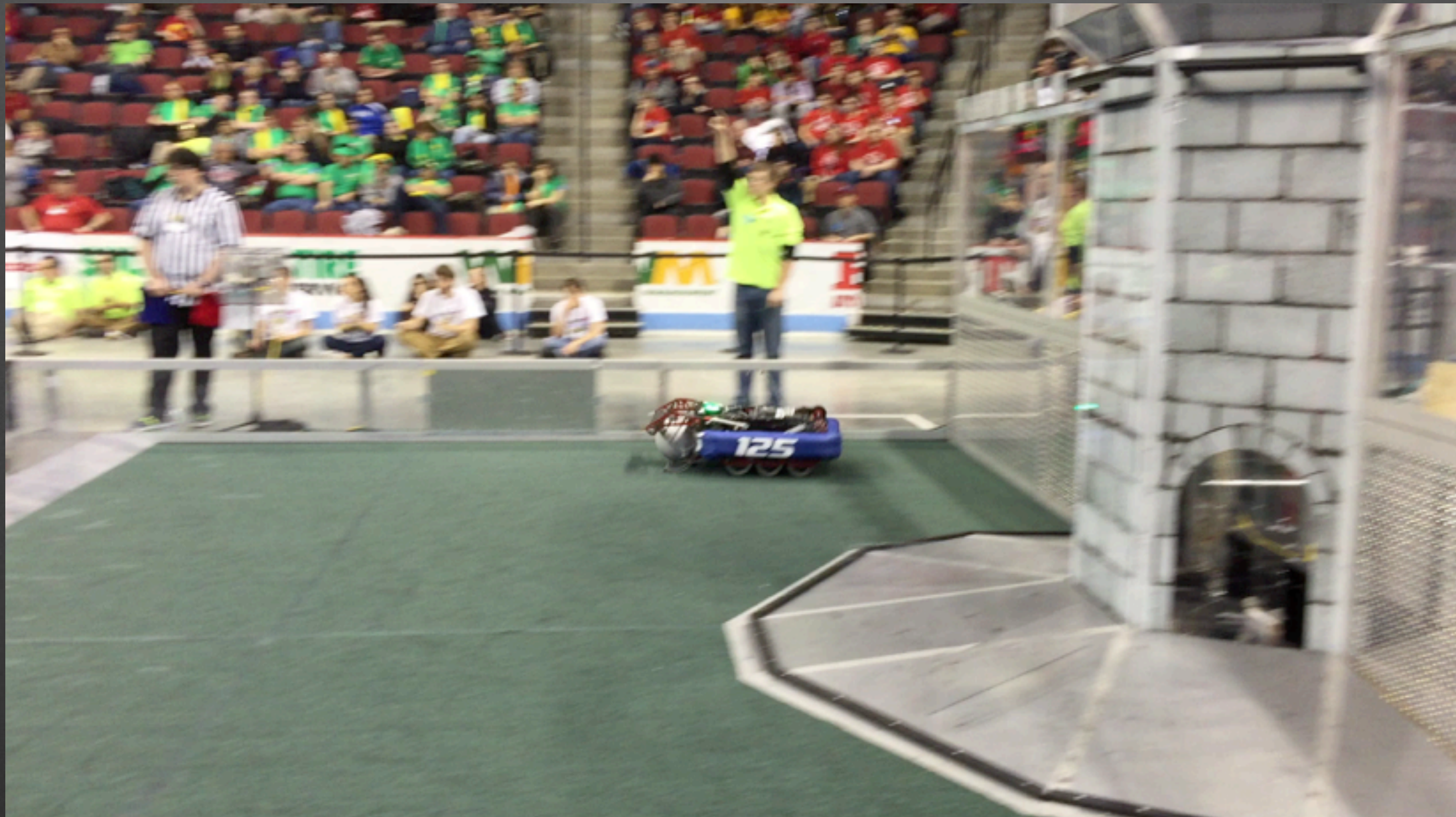
- Axis IP camera connected to the access point
- They point a bright white light at the camera and set the camera to hold with the brightness all the way down rejecting ambient light
- Get the target angle
- Start a PID-based turn with the calculated angle

FRC 125 Neutrons

running GRIP on DS

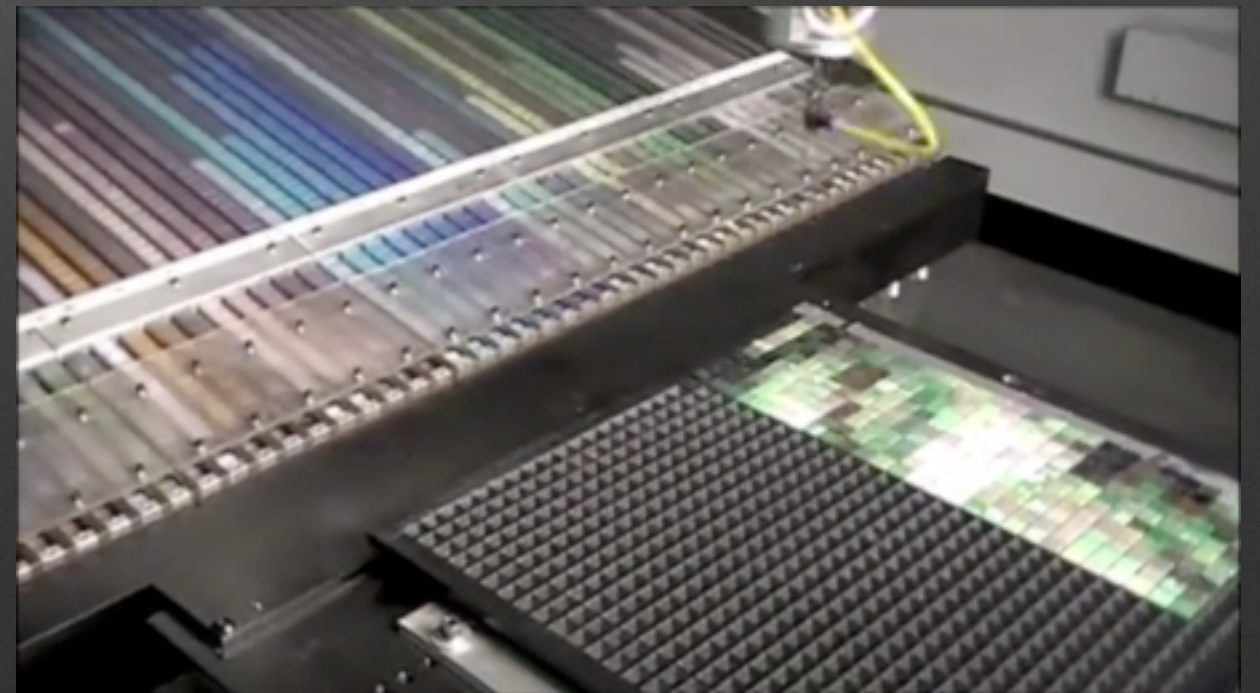


Neutrons in Action



Artaic

- Uses robots to create custom award-winning tile work
- Building a new robot that uses computer vision to locate tiles
- Need to switch pipelines many times per second
- Need to have operators integrate new tile types into workflow without programming
- Using GRIP because it's open source and can switch between pipelines easily



GRIP Results

- What happened in 2016
 - 5000 downloads!
 - Lots of users contributing to the project github
 - Many teams running on roboRIO, driver station and co-processors
 - Memory issues running on roboRIO
- Future features
 - Code generation
 - Improved FRC usage
 - More integration into research environments

A quick demo

Ultimate Simplicity

- Like Jeff Goldbloom said in Jurassic Park, “life finds a way”
- No camera - just a flashlight for aiming with the vision sensor being the drivers at the driver station



WPILib C++/Java futures

- Improved camera support
- OpenCV pre-built libraries and projects
- More/better sample programs