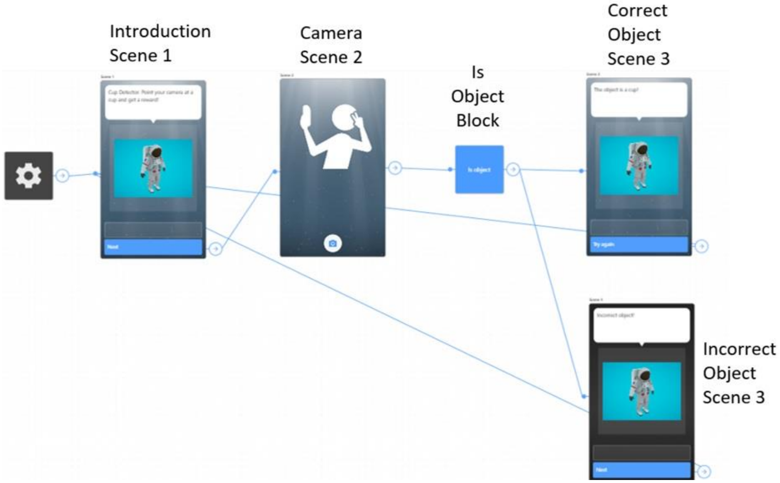
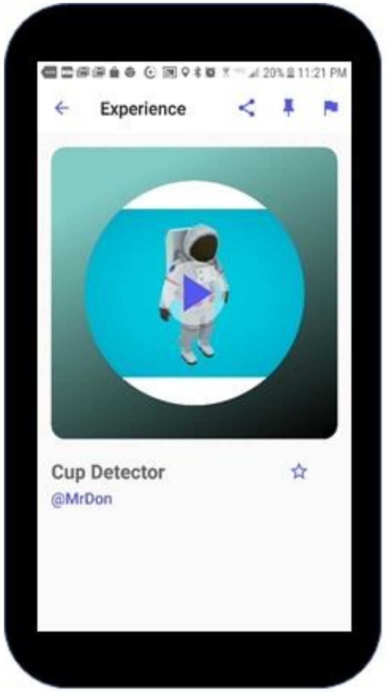
Exploring Vision Devices

Class 1: Embedded Vision Systems Research





August 26, 2019

Don Wilcher

DesignNews

CEC CONTINUING EDUCATION CENTER

Presented by:

Digi-Key ELECTRONICS

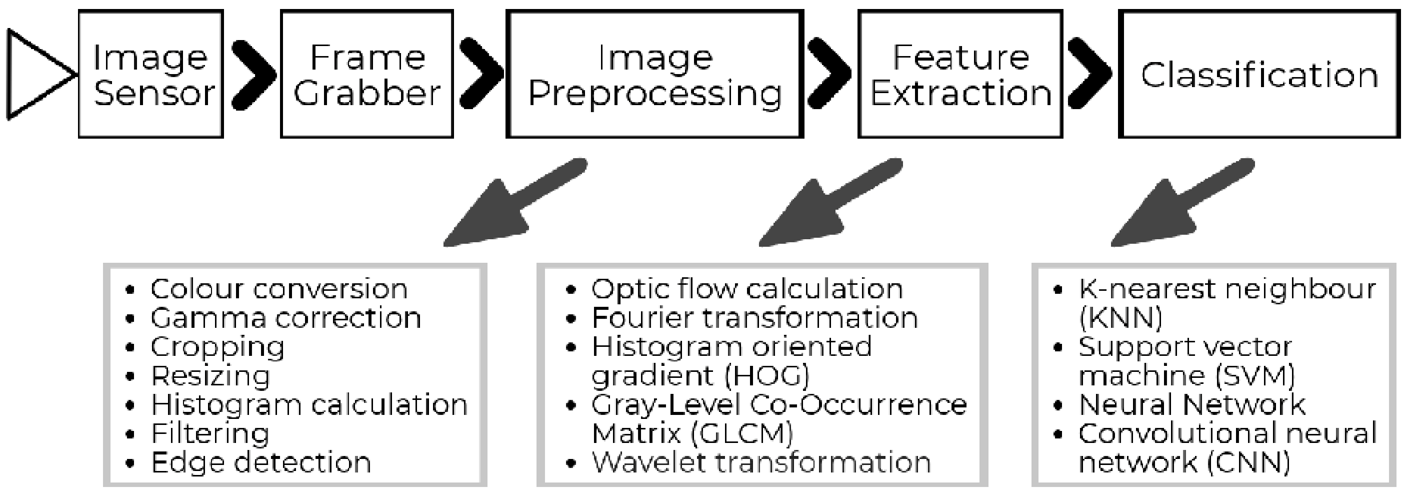
Class 1: Embedded Vision Systems Research

Agenda

- Application specific vision systems: Vision System Pipeline
- Image Sensor Simulator
- Lab Project: Build an Augmented Reality (AR) based smartphone vision device

Application specific vision systems

A common pipeline is used to show major functional characteristics of a typical embedded vision system (Bhowmik & Appiah, 2018).



Vision system pipeline

Bhowmik, D., & Appiah, K. (2018). *Embedded vision systems: A review of the literature*. Retrieved from https://dspace.stir.ac.uk/retrieve/912d91dd-f3c6-44cc-96dc-a8c720167ace/Paper_73.pdf

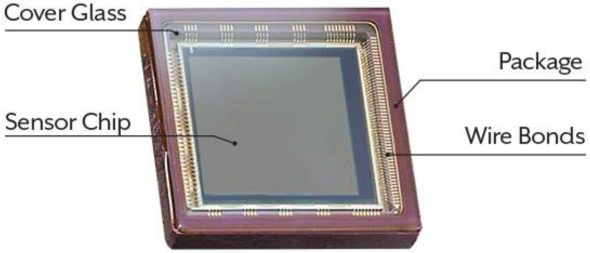
Application specific vision systems…

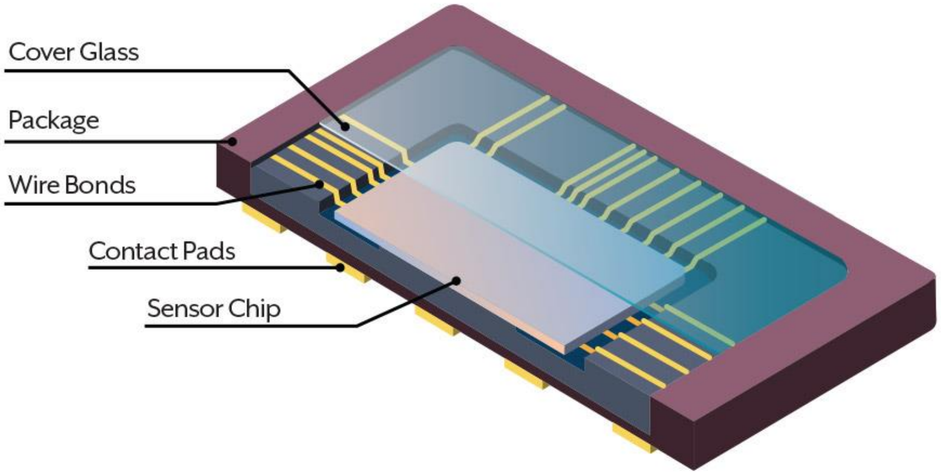
The entry point of the Vision system pipeline is the image sensor. The image sensor consists of:

a) **pixels – built from light sensitive elements**

b) **micro lenses**

c) **micro electrical components**





Typical image sensor

Application specific vision systems…

Frame Grabbers

The **frame grabber** takes the image sensors' signal and controls the frame synchronization and frame rate. Characteristics of frame grabber are:

a) microcontroller based electronics pcb

b) Attaches to a laptop internally

c) uses a mini card slot for internally connection

d) Captures individual digital still frames from an analog video or digital video stream

d) software is used for frame synchronization and frame rate

Question 1:

What is the entry point to the Vision pipeline?

Application specific vision systems…

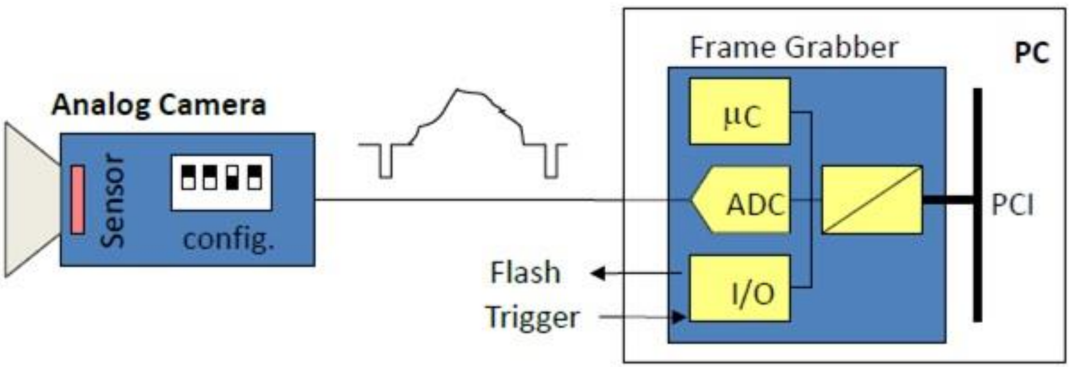
Frame Grabbers:
Hardware Examples

PIXCI EB1miniG

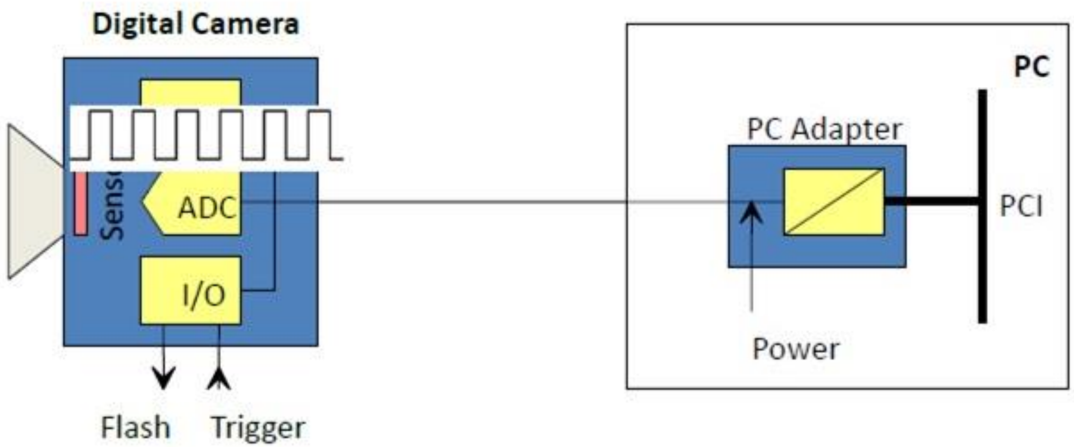
PIXCI EB1miniF

Application specific vision systems…

Frame Grabbers:
Analog vs Digital Cameras



Analog problems:
- Pixel jitter
- Noise
- EMI Susceptibility
- Settings via dipswitch



Digital Solutions:
- Exact pixel readout
- No losses on the cable
- Settings via software

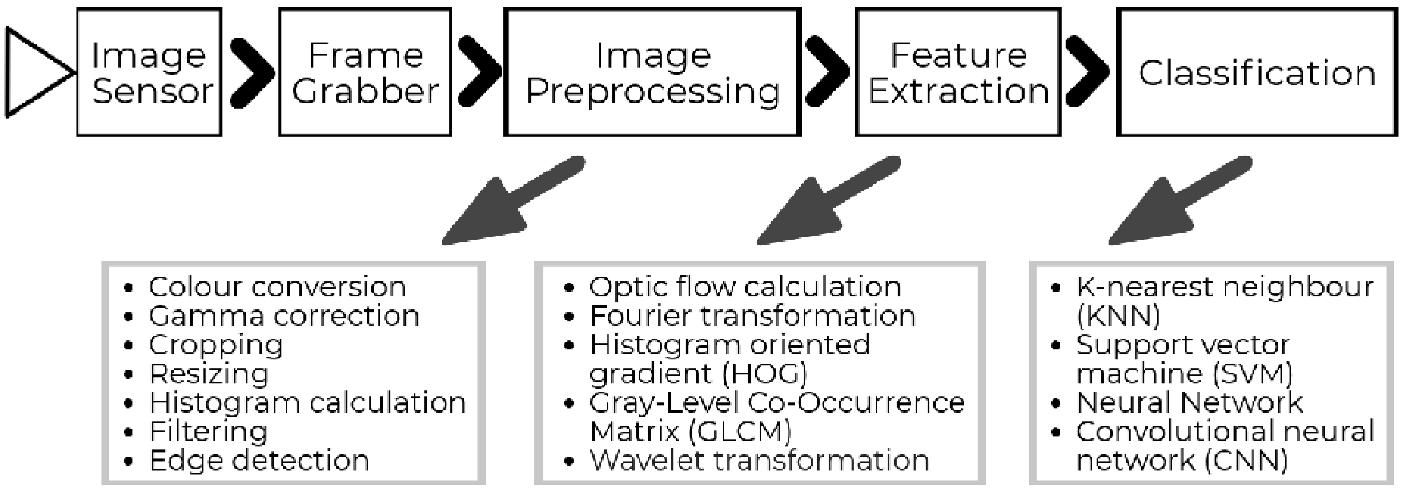
Application specific vision systems…

The raw pixels from the frame grabber are passed to

a) **Image pre-processing**

b) **Feature extraction**

c) **classification**



Application specific vision systems…

Vision Processing

A mechanism used for :

a) information extraction from a digital image

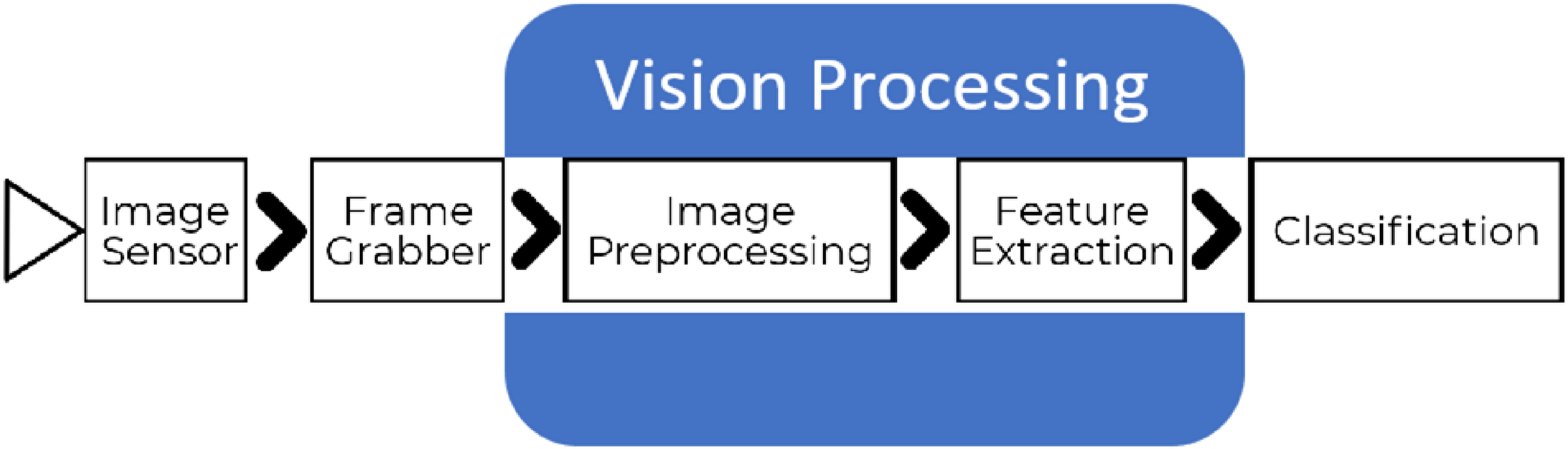
b) software used to process digital image

c) pre-processing used to optimize the image:

- i. ensure features stand out
- ii. runs measurements and compares them to specifications
- iii. decision is made and final results presented

Application specific vision systems…

Vision Processing



Vision system pipeline modified

What is Classification?

Classification Models – Predicts the object membership based on characteristics grouping.

FAQs:

- The focus is on binary decision making.
- Prediction based on a true or false, yes or no 1 or 0 hierarchical format.
- Assigning a task of assigned objects from several predefined categories (Tan, Steinbach et al., 2016).
- Classifications uses Decision Trees to aid in attribute or event predictions.

Source:

Tan, P.N., Steinbach, M., & Kumar, V. (2016). *Introduction to data mining*. Retrieved from https://www-users.cs.umn.edu/~kumar001/dmbook/ch4.pdf

Question 2:

What are the five components for the Vision pipeline?

Image Sensor Simulator

Image Sensor Simulator – an instructional tool that allows the following analysis:

- noise components.
- image quality.
- lighting conditions.
- digital image formulation process.

Image Sensor Simulator…

Camera/Image Sensor Noise Component Basics

Types of Noise Components:

- **Temporal** – Anything besides light that causes a pixel 1’s value to change overtime (sources: temperature, ADC errors, etc)

  a) Shot Noise/Photon Noise:

  b) Best Results: Brighter/Better Light – less shot noise

- **Dark Current Noise** – The rate at which electrons are produced due to thermal effects.

  a) Every 8°C – Dark Noise Doubles:

  b) Best Results: Cooler Camera – less dark noise

Image Sensor Simulator…

Camera/Image Sensor Noise Component Basics

Types of Noise Components:

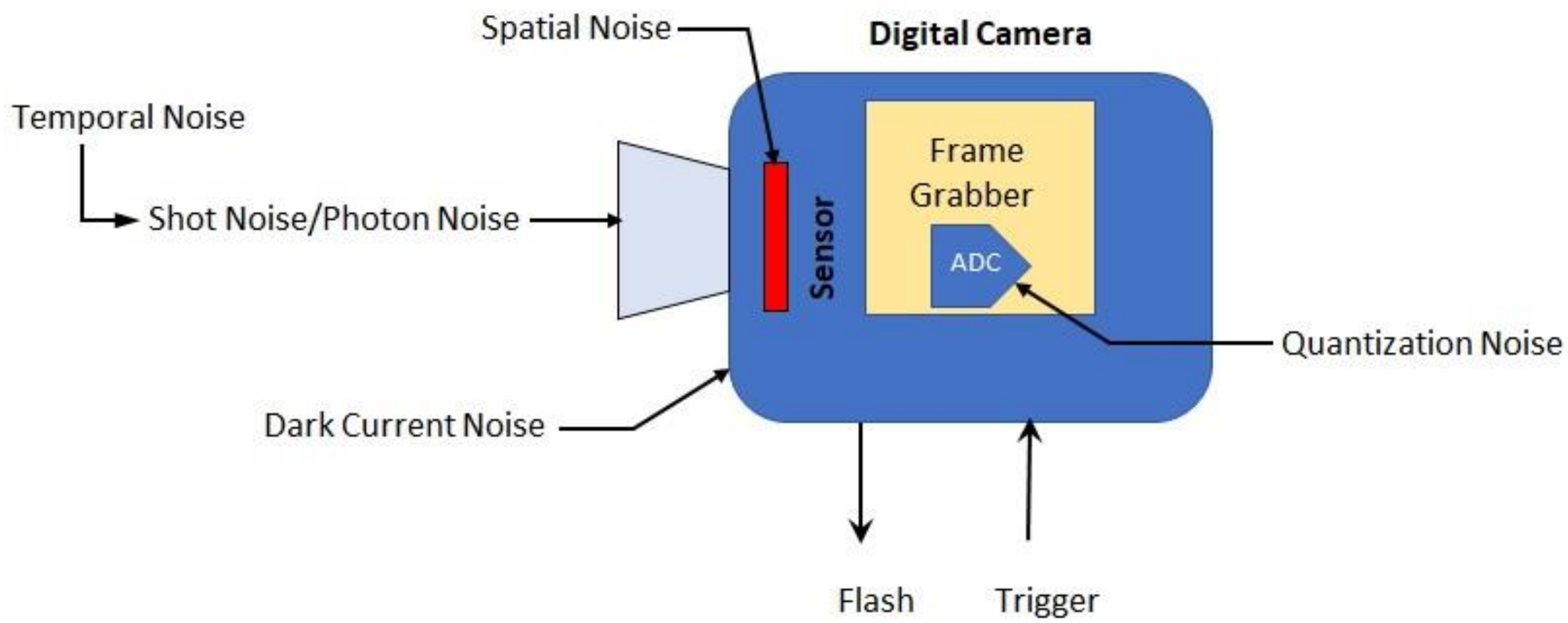
- **Quantization Noise** – Errors coming from the A/D conversion process. **Best Results: Use a better ADC** – less quantization noise

Signal to Noise Ratio (SNR):

- The ratio of a good signal caused by light to unwanted noise
- The most important measurement of image quality for digital cameras**.**

Image Sensor Simulator…

Camera/Image Sensor Noise Components



Question 3:

What noise component is concern with the rate at which the electrons are produced due to thermal effects ?

Image Sensor Simulator…

http://www.pixpolar.com/imager-simulator/index.html

Image Sensor Simulator…

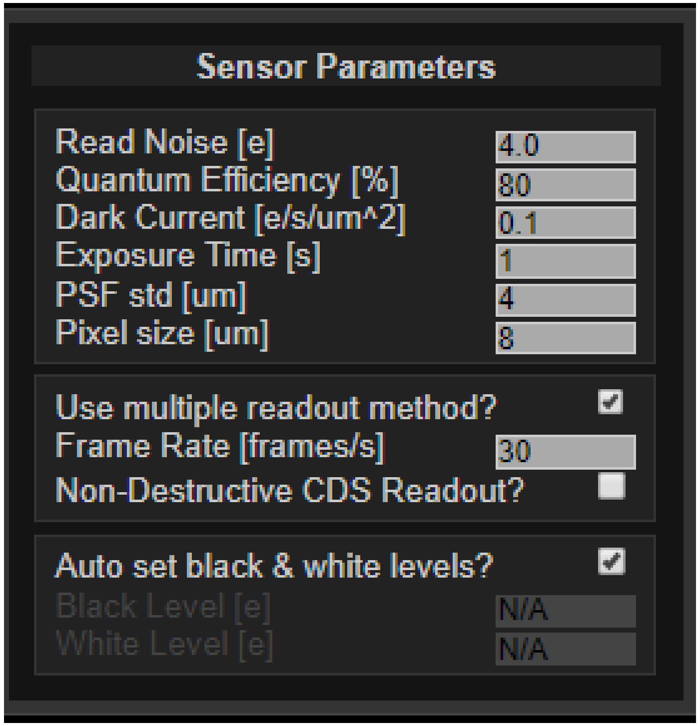


Image Sensor Simulator…

Sensor Parameters Experimentation

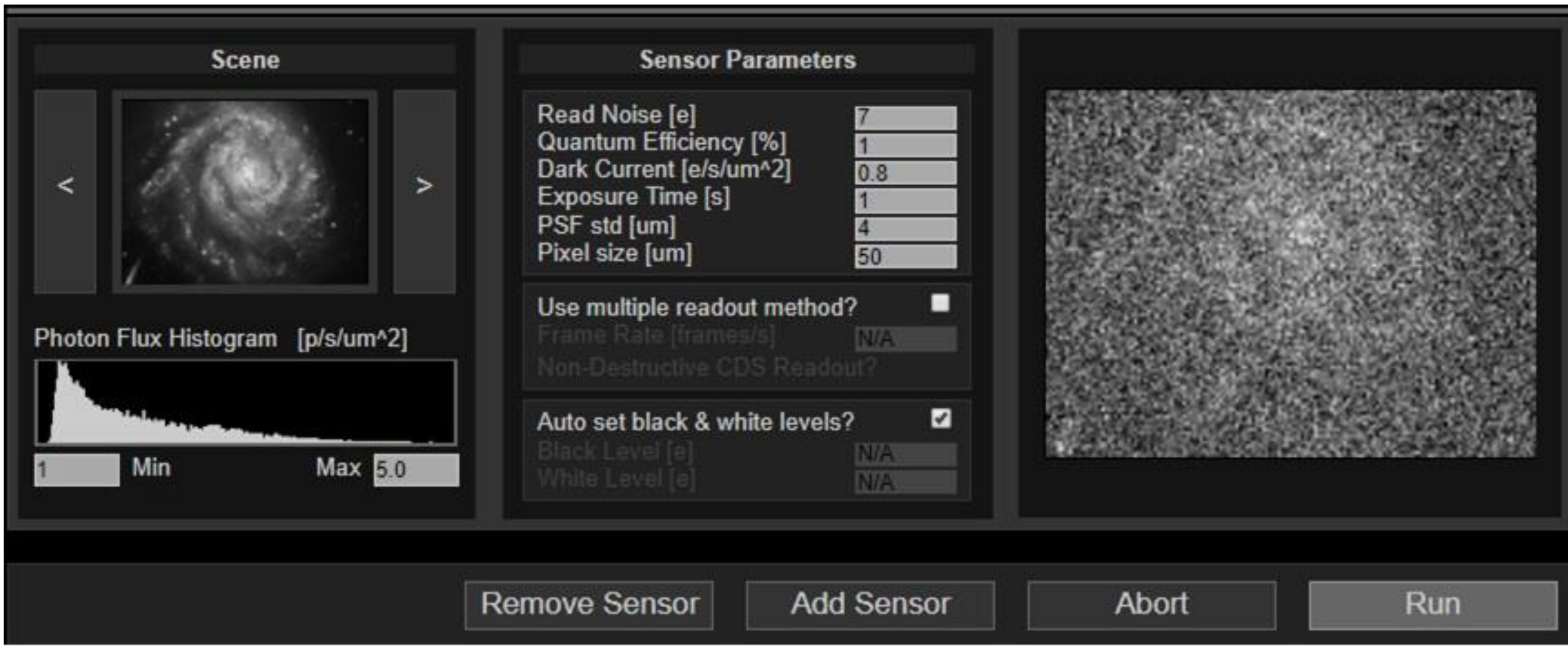


Image Sensor Simulator…

Resource for Image Sensor Simulator

Fundamentals of Image Sensor Performance http://www1.cse.wustl.edu/~jain/cse567-11/ftp/imgsens/index.html

Fundamentals of Image Sensor Performance

Timothy York, timothy.york@gmail.com (A paper written under the guidance of Prof. Raj Jain) Download

Abstract:

Image sensors are everywhere. They are present in single shot digital cameras, digital video cameras, embedded in cellular phones, and many more places. When many people purchase a digital imager, the primary metric they use as a comparison is the pixel array size, expressed in megapixels. The higher the megapixel count, the better the imager is the prevailing wisdom to most consumers. There are many more metrics with which to compare imagers that may give a better indication of performance than raw pixel counts. Further, many of these metrics may be based on the type of imaging technology, CCD (charge coupled device) or CMOS (complementary metal oxide semiconductor). This paper will explain the fundamentals of how a digital image sensor works, focusing on how photons are converted into electrical signals, and thus images. It will detail the difference between the functionality of CCD and CMOS sensors, the two chief architectures for image sensor design. It will also discuss various metrics which are commonly used in analyzing the performance of image sensors. It will include a statistical comparison of recent CCD and CMOS imaging systems from the literature using these metrics, and compare them to some commercially available sensors. It will also develop a model for how two of these metrics, well capacity and conversion gain, are related.

Keywords: Image sensor, CMOS image sensor, CCD, performance analysis, well capacity, conversion gain, image sensor metrics

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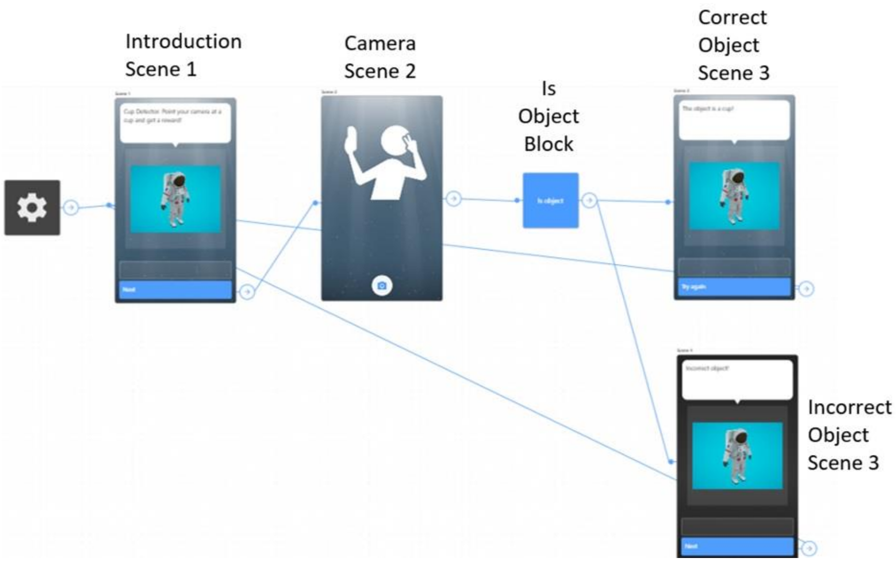
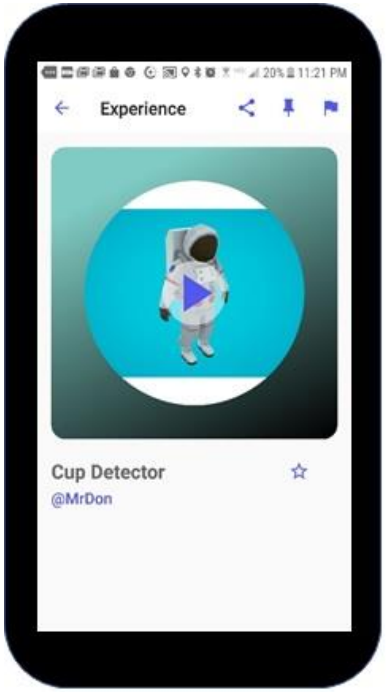
https://www.cse.wustl.edu/~jain/cse567-11/ftp/imgsens.pdf

Lab Project: Build an Augmented Reality (AR) based smartphone vision device…





Lab Project: Build an Augmented Reality (AR) based smartphone vision device

Learning Outcomes

- To use an online design studio software to create AR apps for smartphones.
- To use Google vision block to detect and recognized objects with a smartphone.
- To use the Google API to enable a Machine Learning (ML) feature for object recognition.

Lab Project: Build an Augmented Reality (AR) based smartphone vision device…

metaverse

Create Augmented Reality experiences for iOS and Android, without writing code.

Hundreds of thousands of experiences have been created by regular people from over 180 countries.

Start Creating

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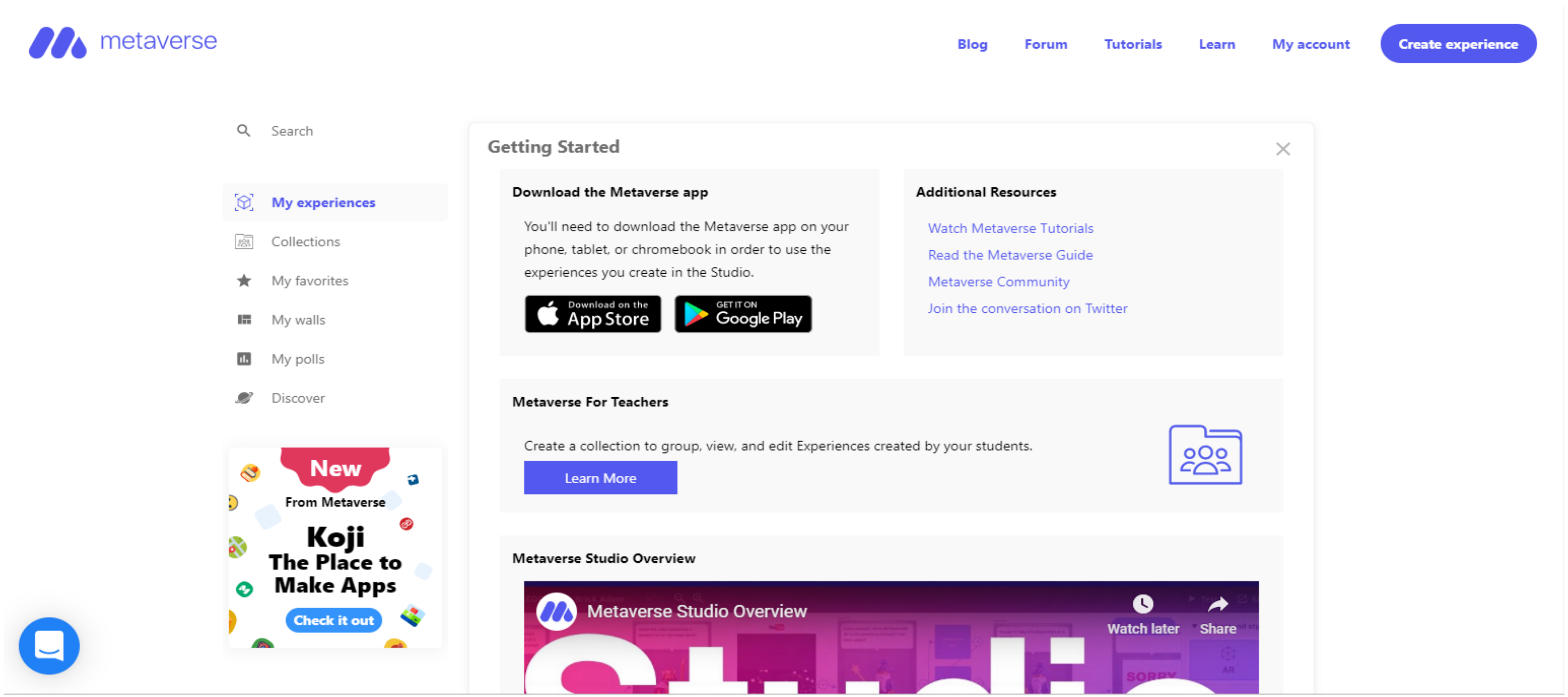
Lab Project: Build an Augmented Reality (AR) based smartphone vision device…

Metaverse AR Studio



Lab Project: Build an Augmented Reality (AR) based smartphone vision device…

Lab Project: Build an Augmented Reality (AR) based smartphone vision device…

Metaverse Mobile App

Getting Started

Download the Metaverse app

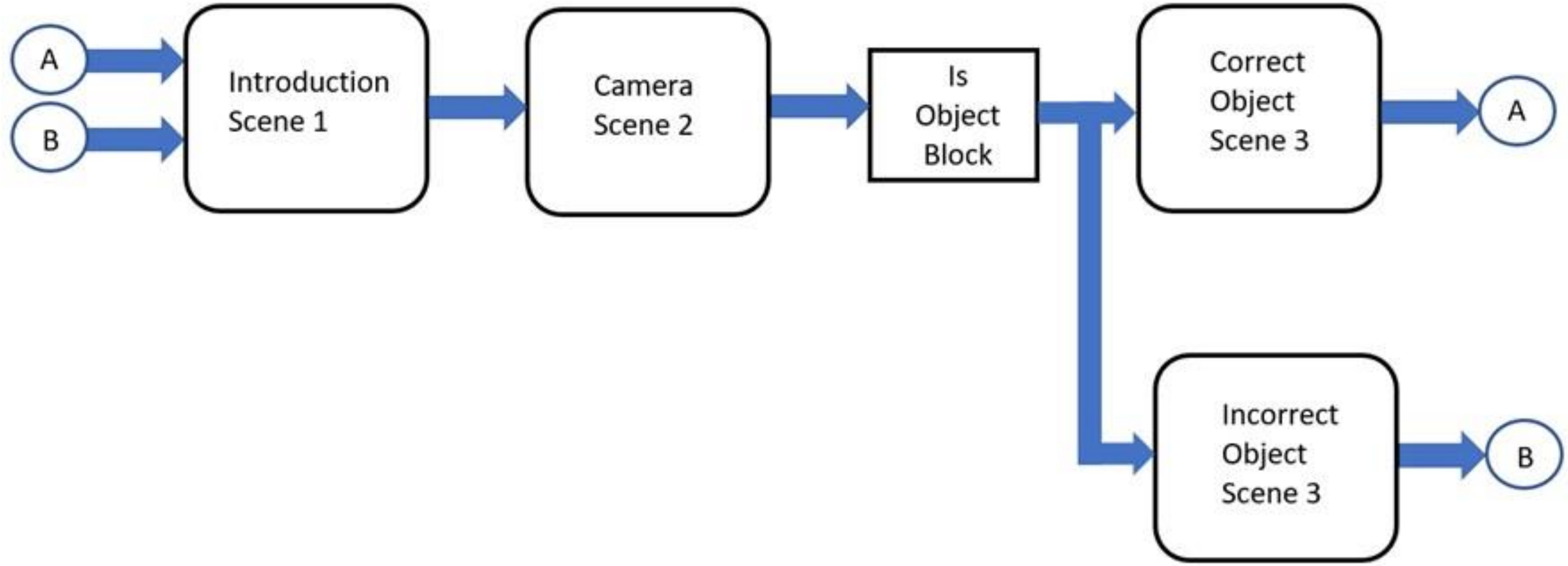
You'll need to download the Metaverse app on your phone, tablet, or chromebook in order to use the experiences you create in the Studio.

Download on the App Store

GET IT ON Google Play

Lab Project: Build an Augmented Reality (AR) based smartphone vision device…

System Design for AR based smartphone vision device



Question 4:

Which image sensor parameter effects the resolution of the image?

Lab Project: Build an Augmented Reality (AR) based smartphone vision device…

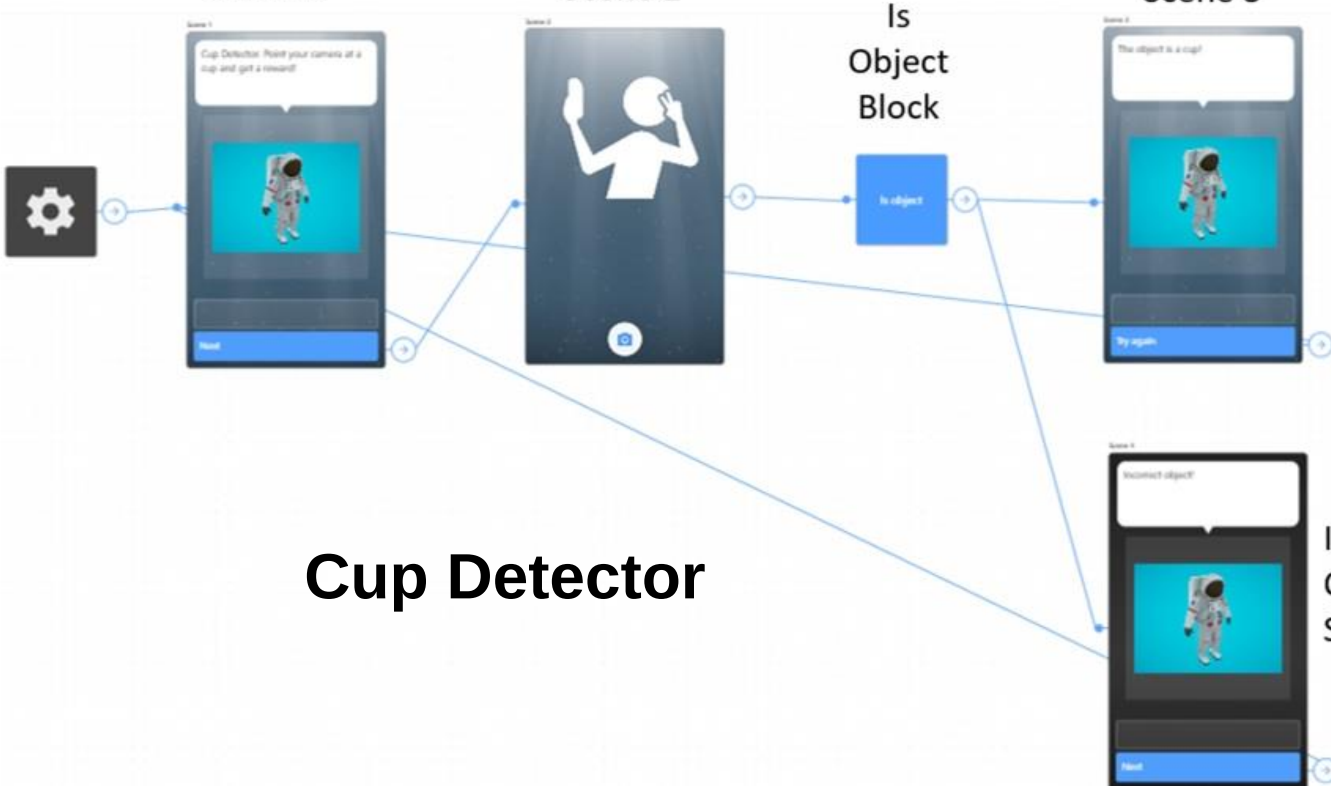
Introduction Scene 1

Camera Scene 2

Is Object Block

Correct Object Scene 3

Incorrect Object Scene 3

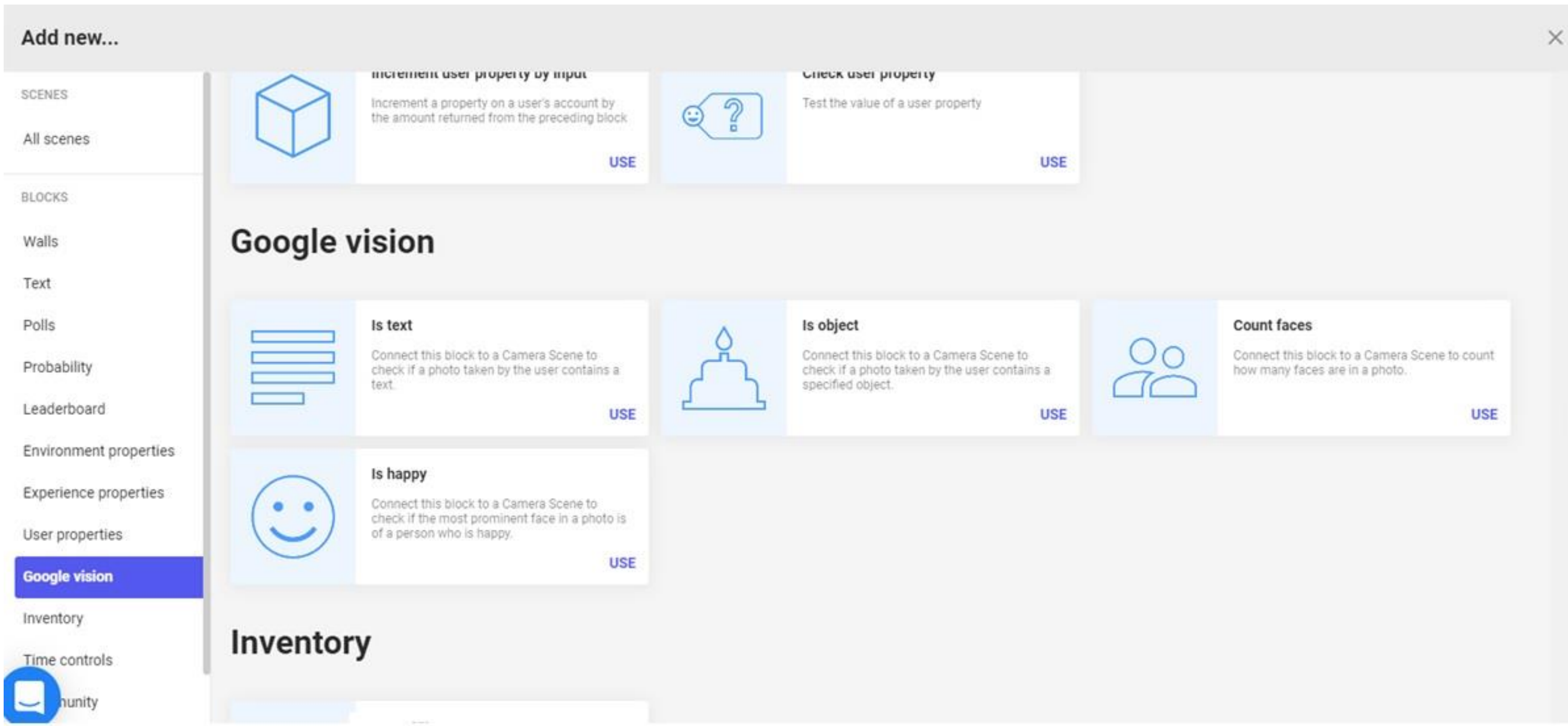


AR smartphone vision device Storyboard

Cup Detector

Lab Project: Build an Augmented Reality (AR) based smartphone vision device…

Google Vision



Question 5:

What instructional design approach is used to develop an AR app using Metaverse?

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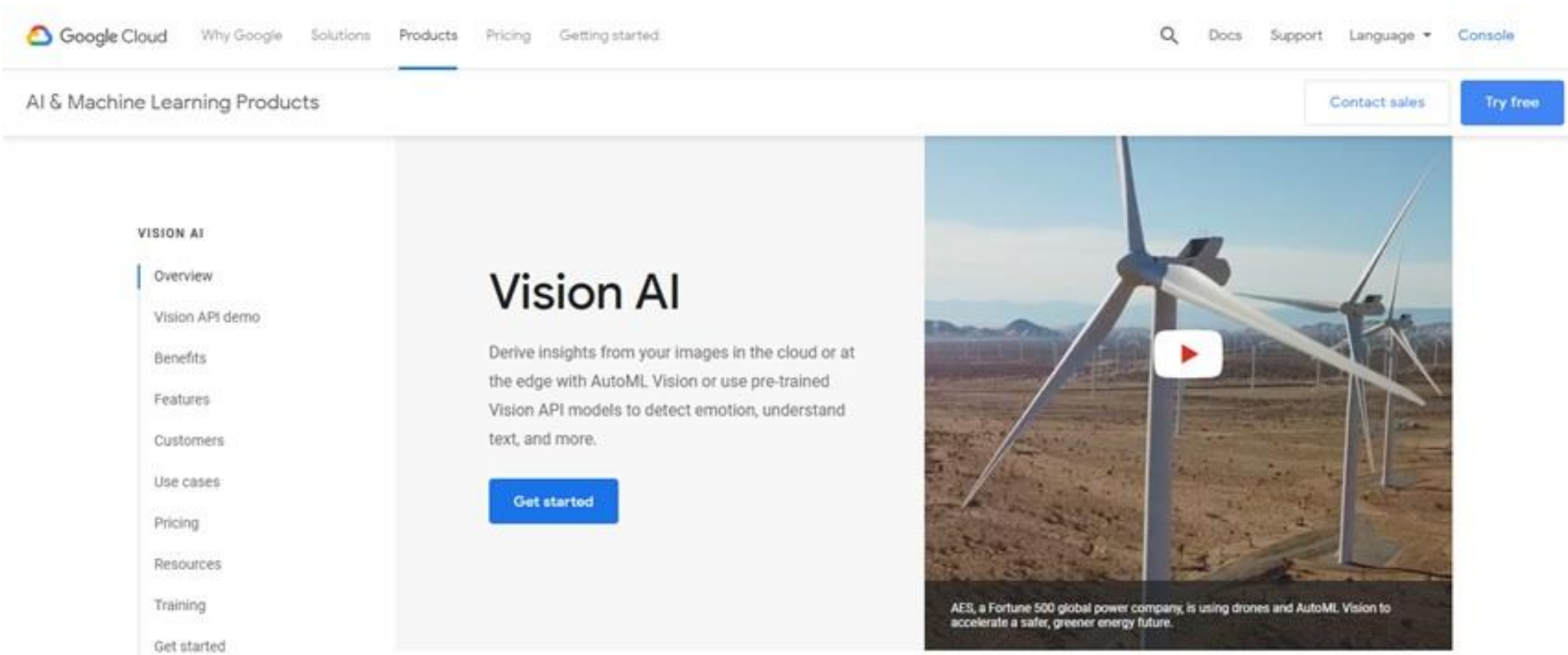
To create object recognition capabilities



https://cloud.google.com/vision/

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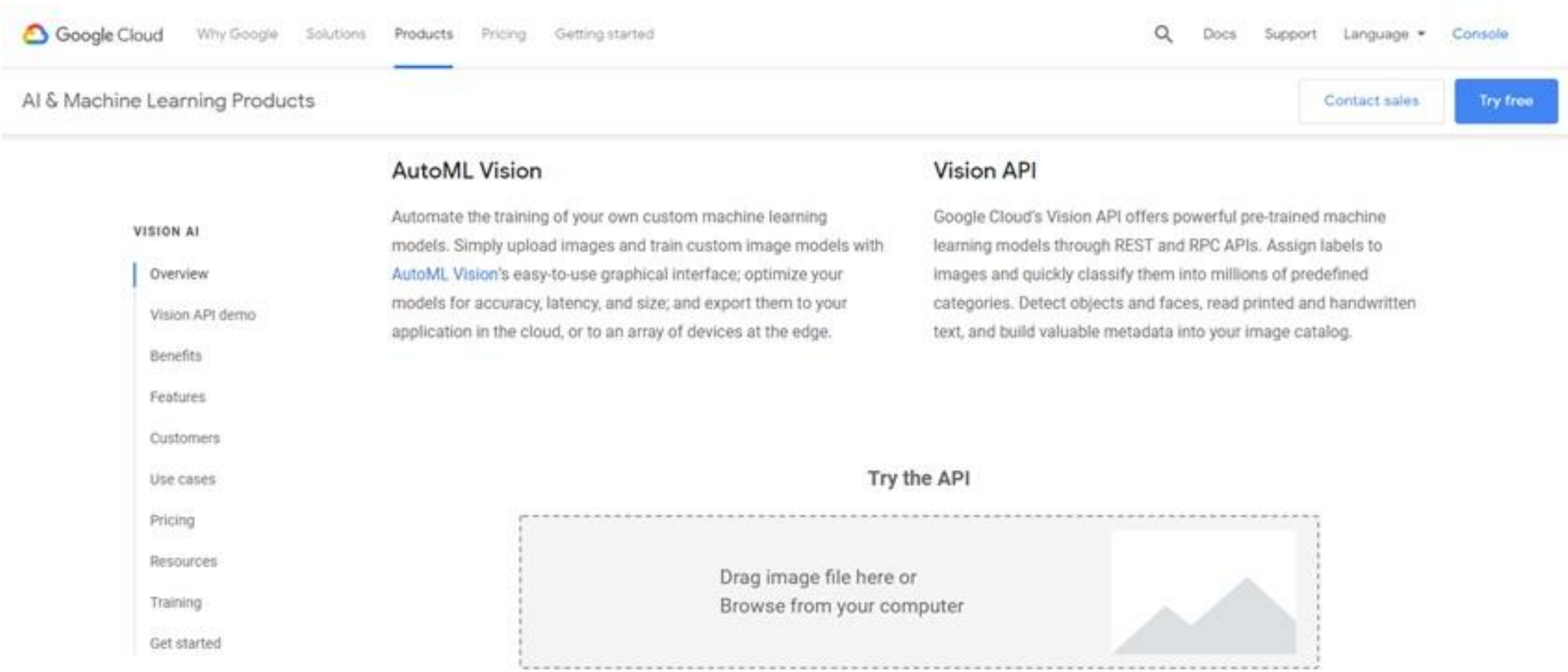
To create object recognition capabilities…



https://cloud.google.com/vision/

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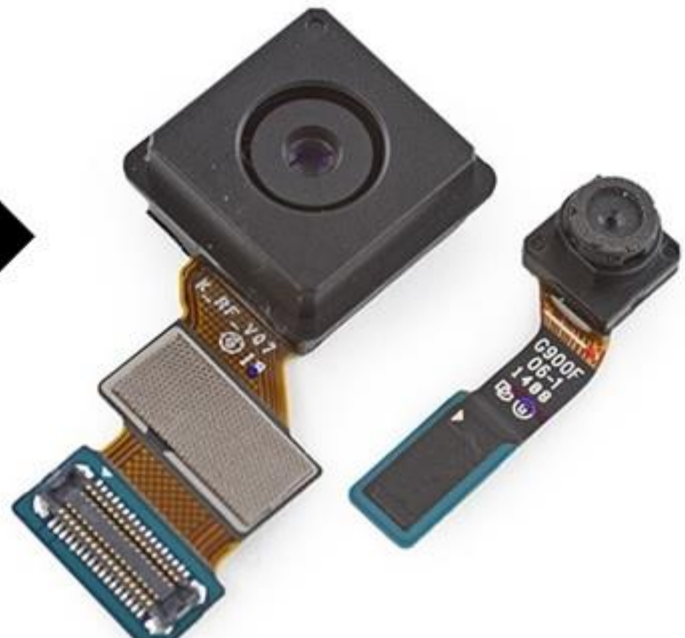
To create object recognition capabilities…

Vision API and AutoML Vison

Smartphone Camera Module



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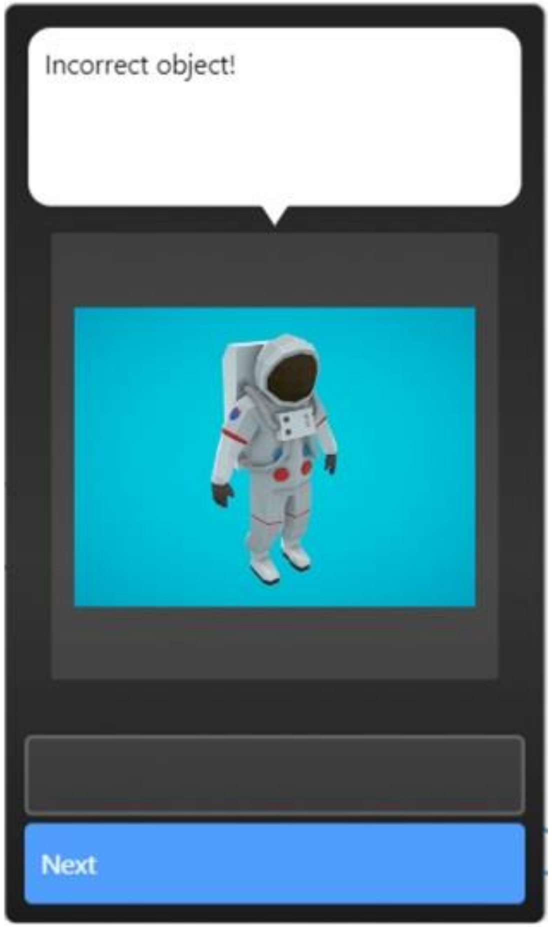

Cup Detector Visual Outputs

Question 6:

What software components are used to create object recognition with a smartphone camera module?

Lab Project: Build an Augmented Reality (AR) based smartphone vision device…

Try It Out with the Metaverse Mobile App!!!