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Improving X-ray Analysis Throughput using Object Detection

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U.S. DEPARTMENT OF ENERGY BATTELLE

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"Improving Radiograph Analysis Throughput using Transfer Learning and Object Detection."

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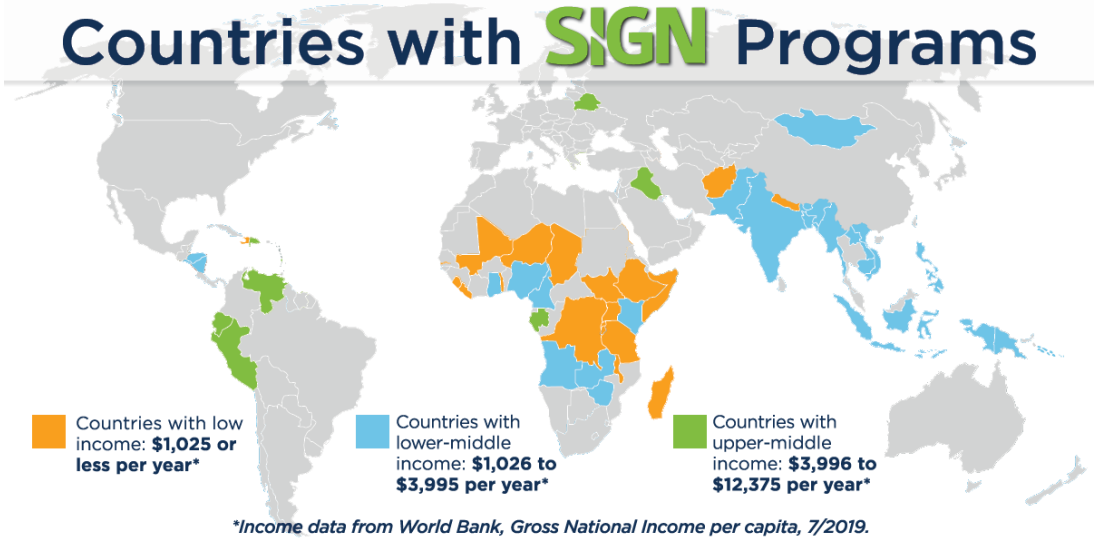
Pacific Northwest NATIONAL LABORATORY + SIGN FRACTURE CARE INT'L based in Richland, WA

Countries with SIGN Programs



Income data from World Bank, Gross National Income per capita, 7/2019.

The SIGN Model

Education + Implants = Healing

Education must be combined with donated implants in order to empower surgeons to provide healing to the poor.

Partnership

Lewis G. Zirkle, MD
President and Founder

Dr. Zirkle founded SIGN in order to bring healing to the injured poor in developing countries.

Today, he gives mentorship to SIGN Surgeons at each hospital, reviews patient cases, and inspires new, innovative design ideas.

SIGN has a large database containing over 125,000 cases with 500,000 associated images, mostly X-rays.

Possibilities

- The data can help us understand what surgical parameters lead to better healing.

Project Goals

Can we use the data to indicate the ideal parameters for successful surgery?

- **Post-op images**
  - ✓Canal between bone and nail
  - ✓Type and location of hardware
- **Follow-up images**
  - ✓Callus size and type
  - ✓Fracture closure

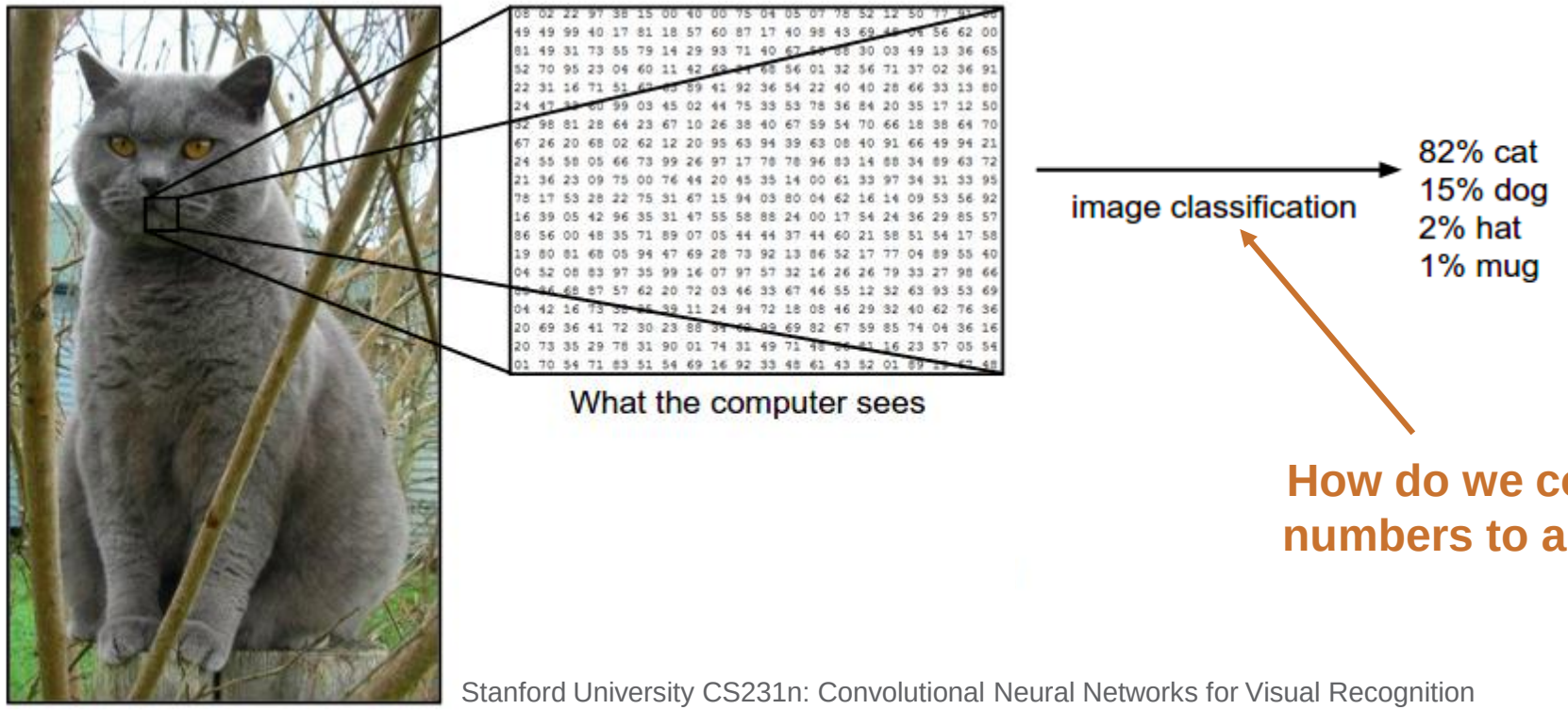
Can we create a model to advise physicians in real time on the best treatment?

- **Pre-op images**
  - ✓Bone that was fractured
  - ✓Location and type of fracture

The computer must learn to “read” X-rays.

What do computers “see”?

- Images are 3D arrays of integers from 0 to 255
  - width * height * color channel (red, blue, green)
- 248 x 400 .jpg image = 297,600 numbers



How do we convert raw numbers to a category?

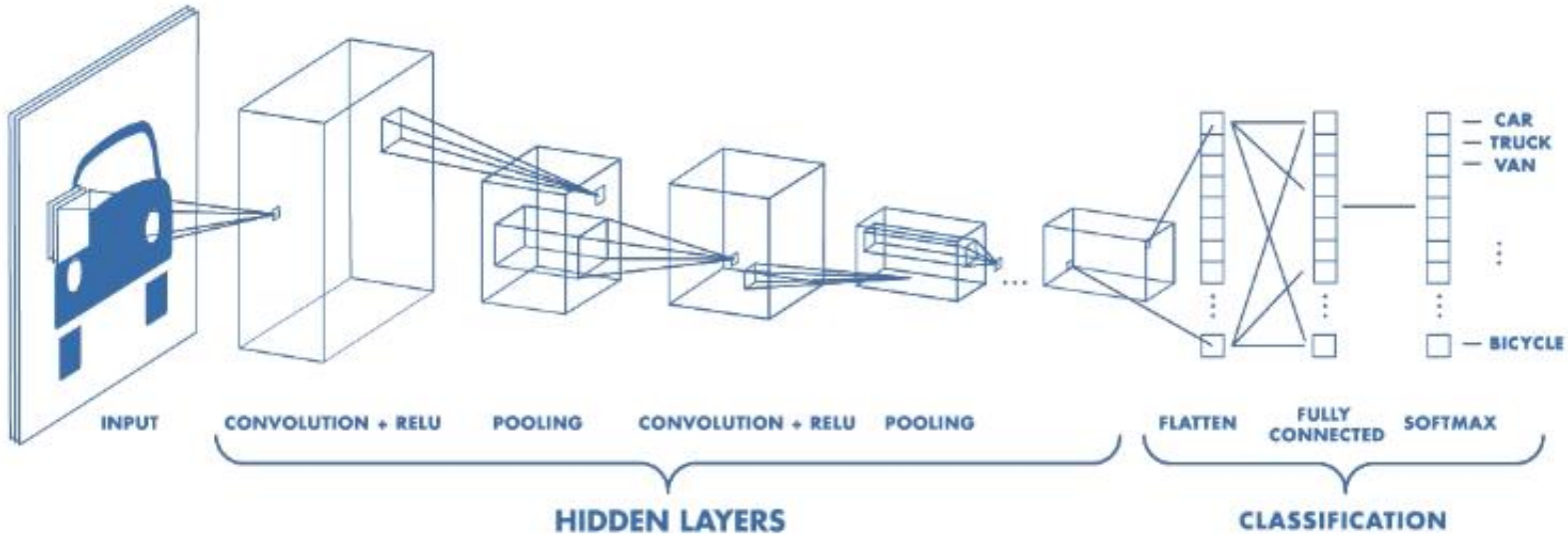
Stanford University CS231n: Convolutional Neural Networks for Visual Recognition

How do computers “see”?

1. Convolutional Neural Network
   - Use image convolution to reduce the size
   - Filter weights are learned during training
2. Classification
   - Weights learned during training
   - Provides the final category value

1x1	1x0	1x1	0	0
0x0	1x1	1x0	1	0
0x1	0x0	1x1	1	1
0	0	1	1	0
0	1	1	0	0

4		



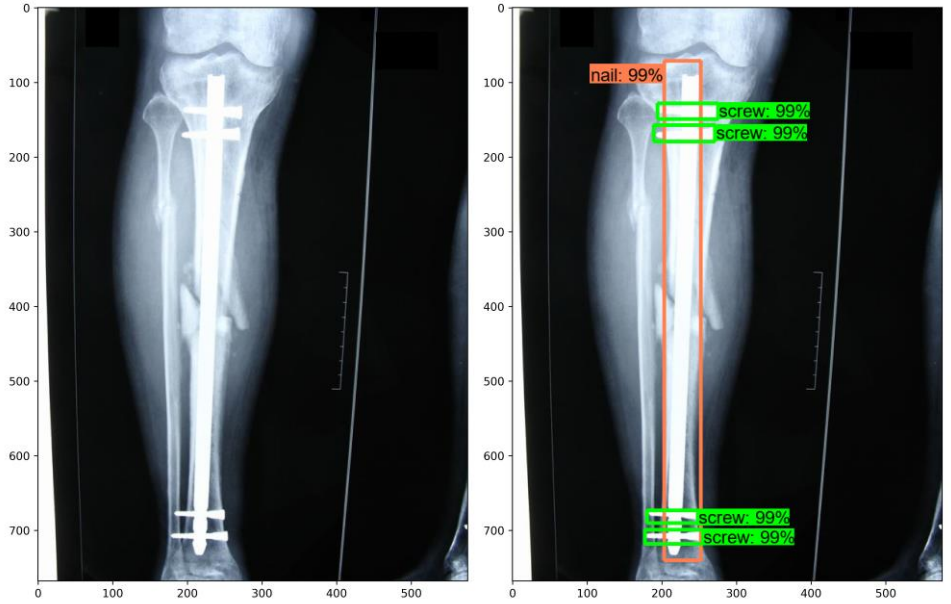
MathWorks: Introduction to Deep Learning: What Are Convolutional Neural Networks?

Type and location of hardware

Objectives

- Quantify the number of screws
- Find placement of nails
- Determine if plates were used

Locate nails, screws, and plates in each image



Implants For Trauma Surgery

Plates

Nails

Screws

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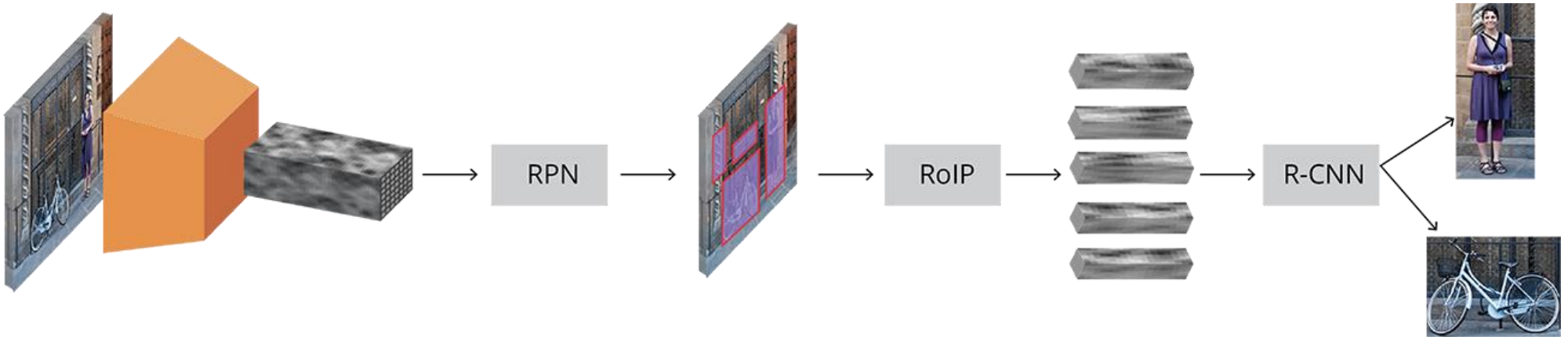
Object detection via deep learning



1. Find potential regions via a region proposal network (RPN)
2. Separate regions via region of interest pooling (RoIP)
3. Classify each region (R-CNN)

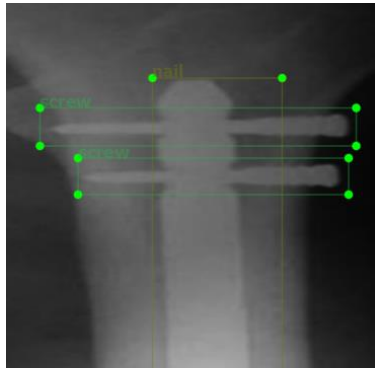
Gives objects in images along with their relative location

$$Precision = \frac{TP}{TP + FP}$$

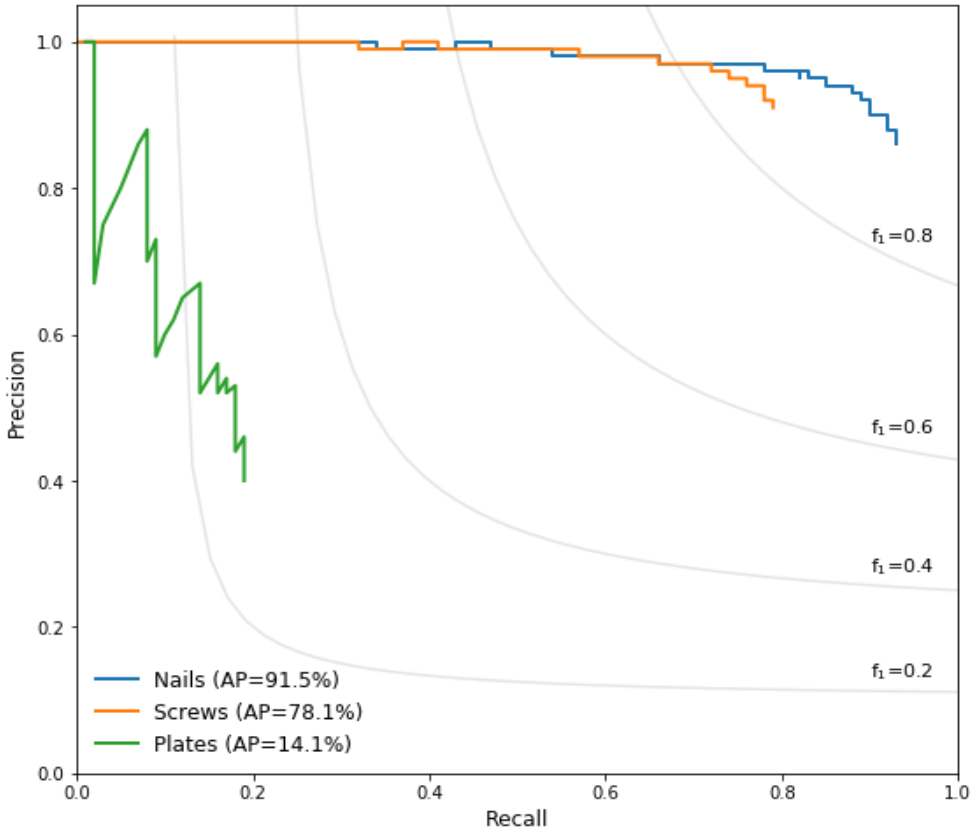
$$Recall = \frac{TP}{TP + FN}$$

TP = True positive
FP = False positive
FN = False negative

Training the object detection network

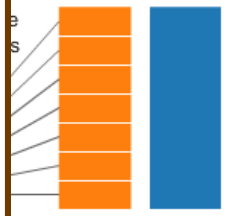


Weighted mAP of 79.1%



Very poor detection of plates!

Class imb
towards cla
Solution: C

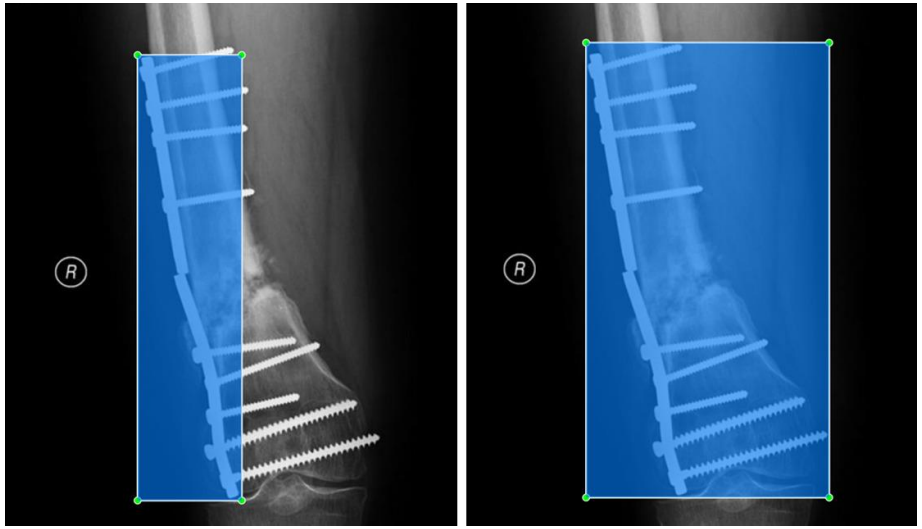


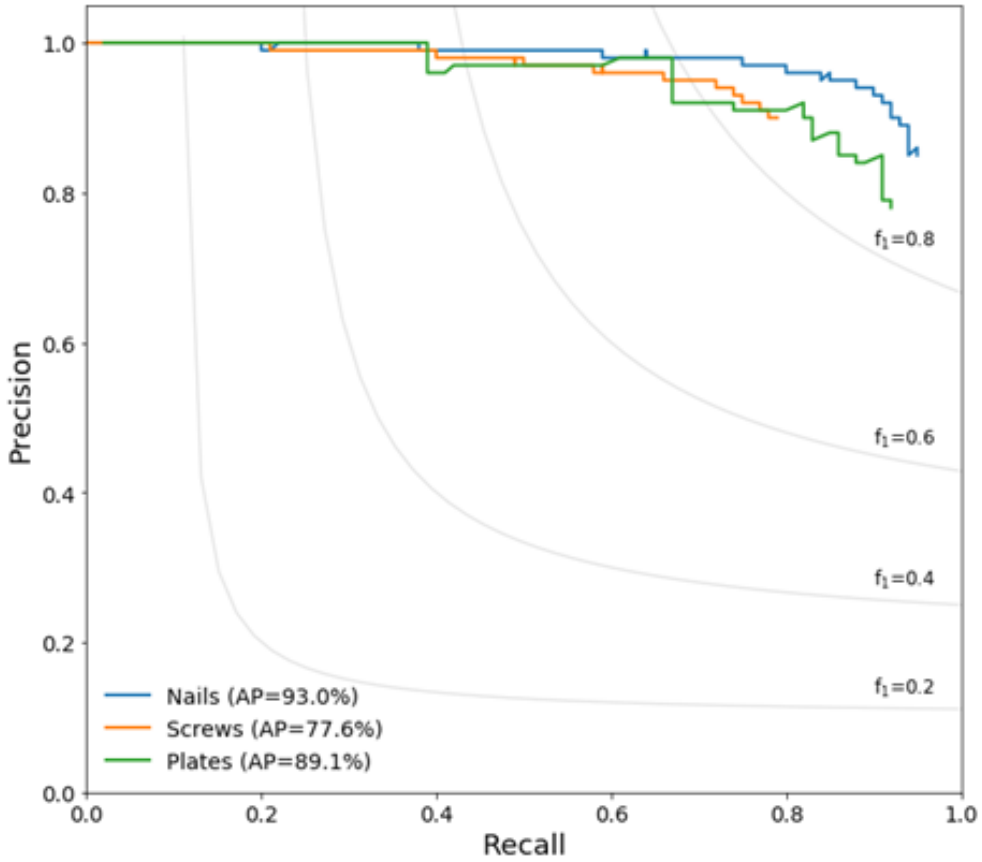
4,67

Class	Cou	er Image
Screw	10	5.6
Nail	3,	1.5
Plate	7	0.8

Improving plate detection

- Plates were relabeled to include screws
- Separate model trained on plates only
- mAP of plates increased to 89.1%





Conclusions

- Deep learning can be used to automatically identify hardware in X-rays
- Image augmentation did not improve plate detection
- Class correlations need to be considered

Can we use the data to indicate the ideal parameters for successful surgery?

Can we create a model to advise physicians in real time on the best treatment?

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