Deep Learning for Image Processing in Orthopaedics

ORS Virtual Scientific Session

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January 4, 2023

A Brief Introduction

“Machine learning, neural networks, and artificial intelligence are increasingly being used in orthopaedics for image processing and analysis tasks. These techniques can be used to **automatically analyze medical images** such as X-rays, MRI scans, and CT scans to **extract important diagnostic information** and help with diagnosis and treatment planning. Machine learning algorithms can be trained to **recognize patterns in the images**, and neural networks can be used to process and interpret the data in a more human-like way. These approaches can be used to **identify abnormalities, measure bone density, and classify different types of tissue**, among other tasks. By automating these processes, doctors and other healthcare professionals can **save time and improve the accuracy of their diagnoses**”

- ChatGPT (emphasis mine)

By the end of this presentation, you should be able to …

- → List some ways that deep learning is being used for image processing in orthopaedics
- → Understand some of the basic neural network architectures, and how those fit into different tasks
- → Have a few tips and tricks up your sleeve for getting started with these networks
- →

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Segmentation	Labeling specific pixels of interest in an image based on desired mask
Detection	Locating regions in images based on presence of specific object

EXAMPLES

Automated Segmentation and Grading of Rodent Knee OA Histology using Convolutional Neural Networks

Jacob Griffith[1], Andrew Jensen[2], Scott Banks[2,4], Kyle D. Allen[1,2,3,4]

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2. Department of Mechanical and Aerospace Engineering at the University of Florida, Gainesville, FL
3. Pain Research & Intervention Center of Excellence (PRICE), University of Florida, Gainesville, FL
4. Department of Orthopedics and Rehabilitation, University of Florida, Gainesville, FL

Current Results

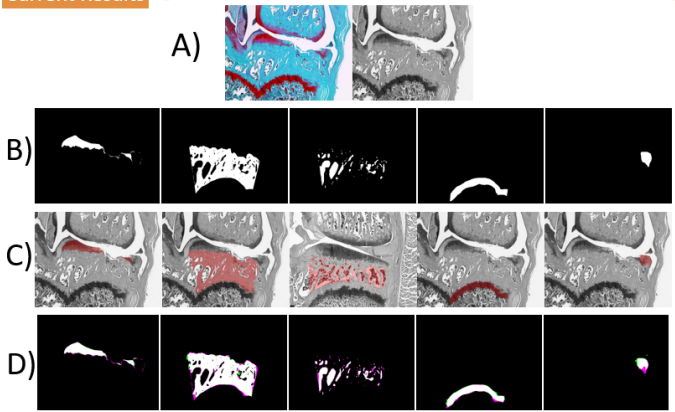
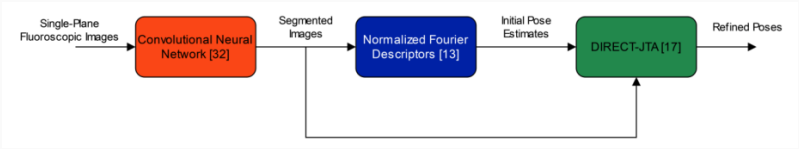
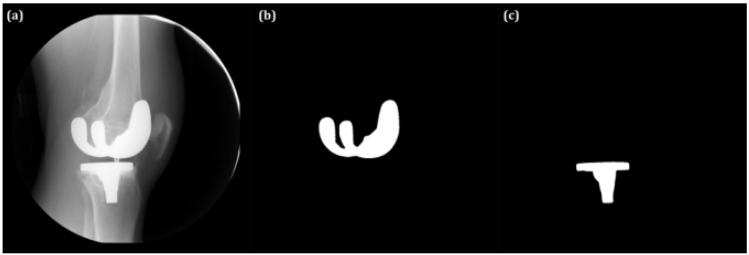


Figure 2. Example images of **A)** Raw histological images in RGB and grayscale color spaces, **B)** binary masks from manually segmented regions of interest (ground truth), **C)** HRNet estimated segmentation overlayed on the original histological image, and **D)** visualization of the Jaccard Index where pink is false negative, and green is false positive.

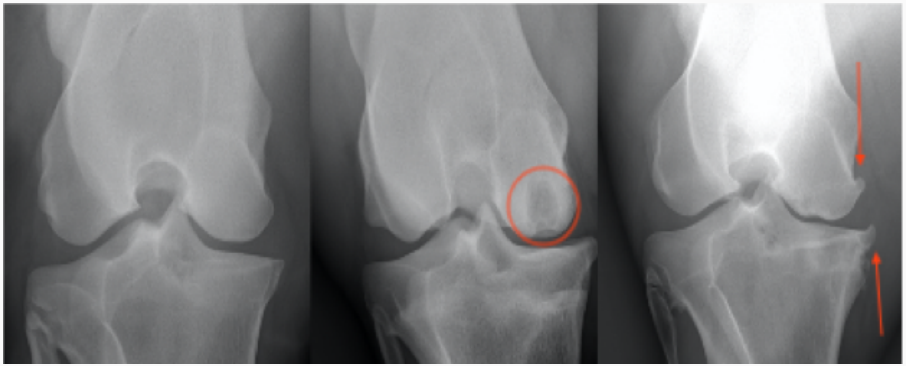
Joint Track Machine Learning: An Autonomous Method of Measuring TKA Kinematics from Single-Plane Images

Andrew Jensen, Paris Flood, Lindsey Palm-Vlasak, Will Burton, Paul Rullkoetter, Scott Banks





Classification of Equine Stifle Pathology



Artificial Intelligence to Identify Arthroplasty Implants From Radiographs of the Knee

Jaret M. Karnuta, MS [a], Bryan C. Luu, BS [a, c], Alexander L. Roth, MD [a], Heather S. Haeberle, MD [a, b], Antonia F. Chen, MD MBA [d], Richard Iorio, MD [d], Jonathan L. Schaffer, MD MBA [a], Michael A. Mont, MD [e], Brendan M. Patterson, MD MBA [a], Viktor E. Krebs, MD [a], Prem N. Ramkumar, MD MBA [a, d, *]

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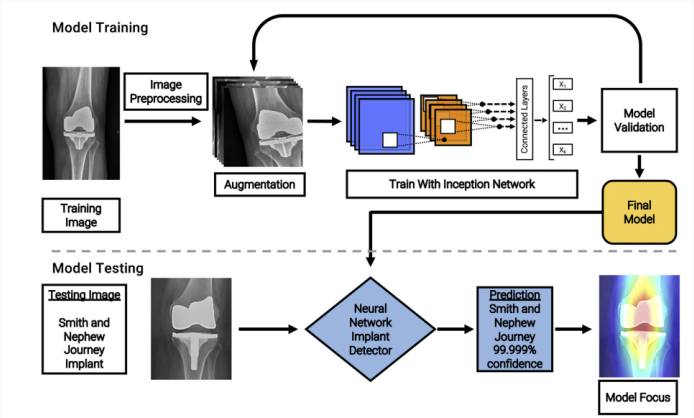
[b] *Department of Orthopaedic Surgery, Hospital for Special Surgery, New York, NY*
[c] *Department of Orthopaedic Surgery, Baylor College of Medicine, Houston, TX*
[d] *Department of Orthopaedic Surgery, Brigham & Women"s Hospital, Boston, MA*
[e] *Department of Orthopaedic Surgery, Lenox Hill Hospital, Northwell Health, New York, NY*



Deep High-Resolution Representation Learning for Visual Recognition

Jingdong Wang, Ke Sun, Tianheng Cheng, Borui Jiang, Chaorui Deng, Yang Zhao, Dong Liu, Yadong Mu, Mingkui Tan, Xinggang Wang, Wenyu Liu, and Bin Xiao

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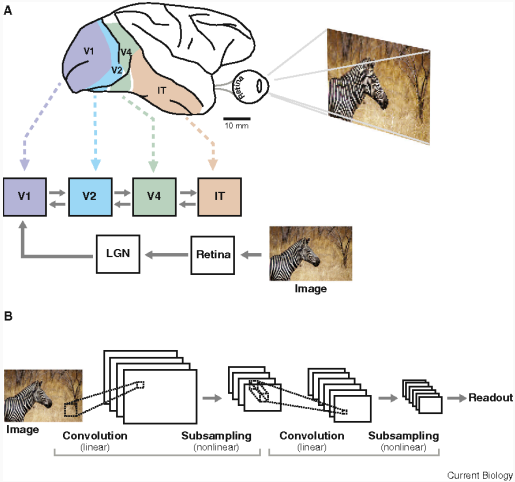
Fig. 6. Qualitative COCO human pose estimation results over representative images with various human size, different poses, or clutter background.

WHAT IS DEEP LEARNING FOR IMAGE PROCESSING?

A Basic Definition

→ Subset of machine learning using neural networks to imitate the visual system in the brain

→ A set of algorithms that learn programs from data



Cox and Dean, Neural Networks and Neuroscience-Inspired Computer Vision, 2014

The Architecture of a Neural Network

Building Block	Neural Network

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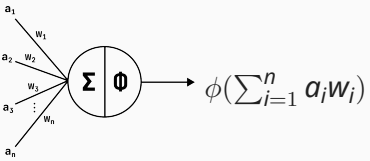	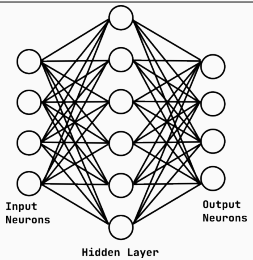

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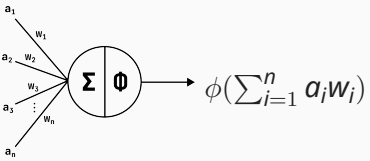
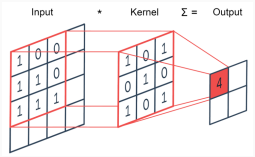
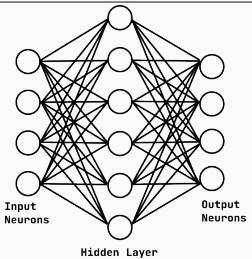
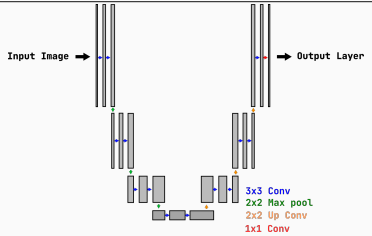


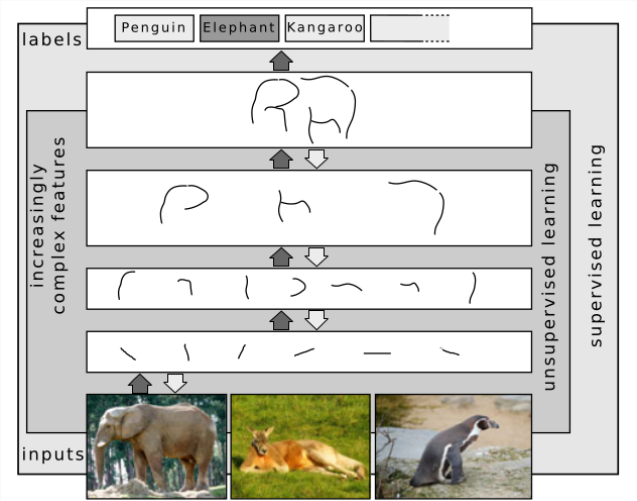


Neural Network





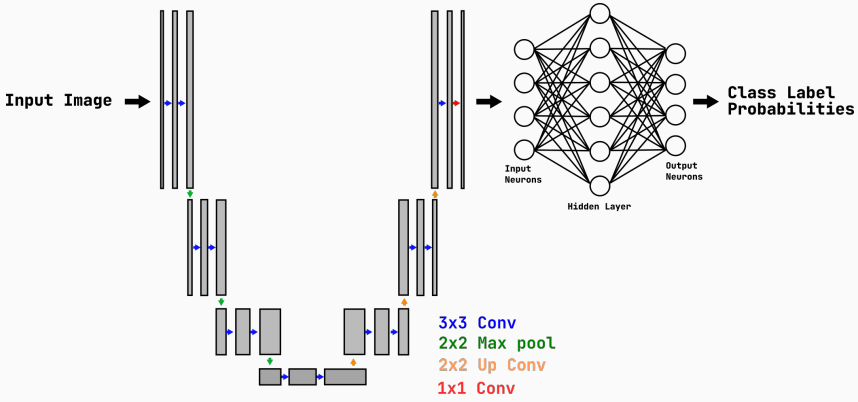
The Power of Convolutional Neural Networks



Shulz and Behnke, Deep Learning: Layer-Wise Learning of Feature Hierarchies, 2012

ARCHITECTURE MODIFICATIONS

Classification



Segmentation