

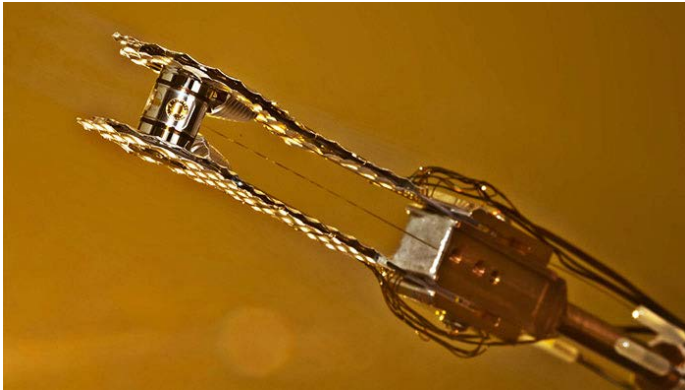
# Transfer Learning Applications toward ICF Capsule Manufacturing

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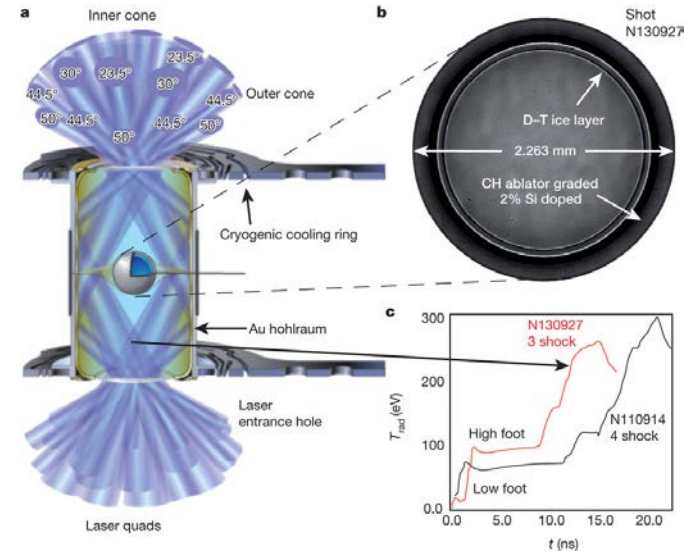
Aug 7, 2018



# Fuel for ICF targets is loaded into small capsules



- Small capsules inside complex assembly
- Capsules must be perfect
  - Defects grow exponentially



Fuel gain exceeding unity in an inertially confined fusion implosion. O. A. Hurricane et. al. Nature vol. 506, 2014



# Detecting bad capsules early improves throughput

- Quality control has two passes
  - First pass: cheap
    - Top & bottom pictures taken of shells
    - 1 person at General Atomics reviews images
      - Only 1 person for consistent evaluation
    - Bad shells thrown away.
  - Second pass: expensive
    - Good shells get examined via atomic force microscope
    - Bad shells thrown away



# Human Operator Accuracy

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- An operator was asked to reclassify 206 images
- Percentage classified correctly
  - 83% of the GOOD images
  - 68% of the BAD images
  - 75% overall
- Accuracy is subjective and fluctuates depending on current standards

# Can machine learning replace the first screen?

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- Goal: Remove the human from the loop
  - Humans make mistakes
  - Humans are slow
  - Looking at thousands of images is boring
  
- Stretch goal: do better than humans

# ResNet18

- Extensive work w/ ResNet
  - used as a baseline for comparison
- ResNet yields higher accuracies compared to VGG16 (initially used by Dr. Boehm)
- Varying the # layers frozen in ResNet
  - increasing the # of trainable layers improved validation accuracy
- Modified:
  - data augmentation
    - crop
    - flip
  - dropout
  - additional FC layers

# Modern Convolutional Neural Networks

- These architectures:
  - take advantages of modern image classification techniques
  - increased accuracy or reduced model size
- SqueezeNet
  - small, low-parameter model
- DenseNet
  - heavily connected convolutional layers

# SqueezeNet (ICLR 2017)

## landola et al.

- Smaller CNNs offer 3 advantages
  - Much smaller models
    - 50x fewer parameters
    - 500x less memory
  - Fast inference speed
  - Reduced overfitting
- Good for small datasets
- Accuracy not as good as top 5 models

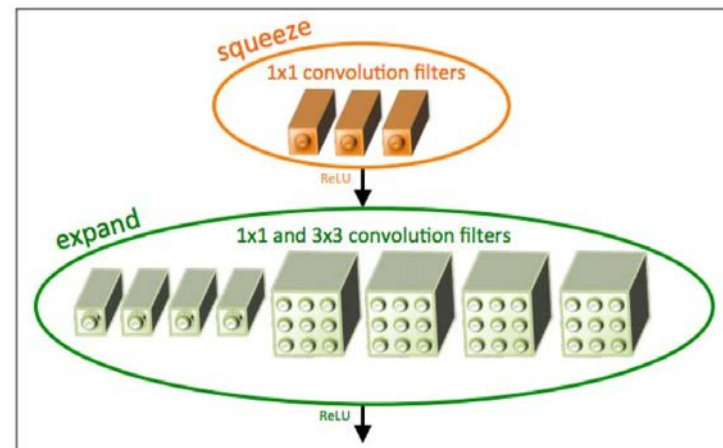
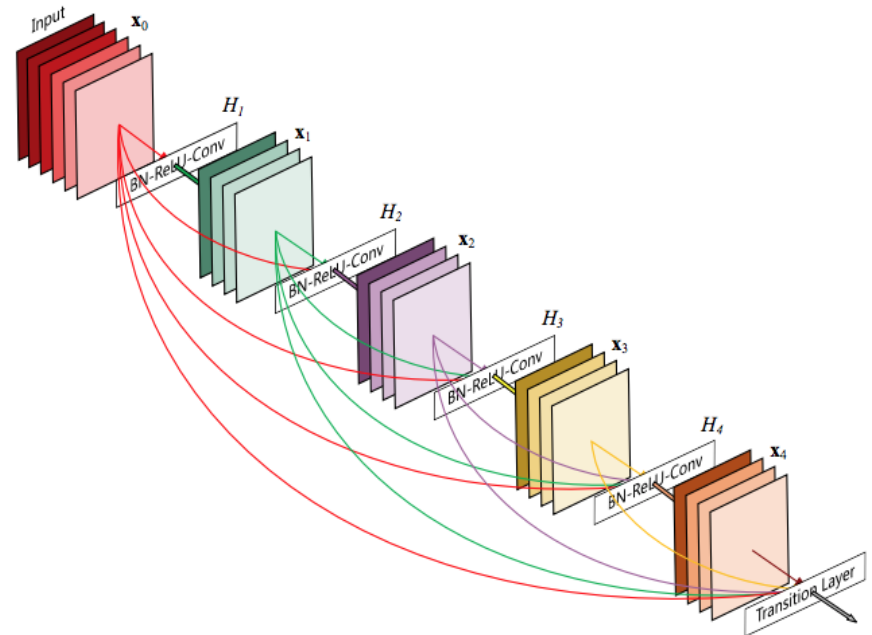


Figure copyright landola, Han, Moskewicz, Ashraf, Dally, Keutzer, 2017. Reproduced with permission.



# DenseNet (CVPR 2017 best paper)

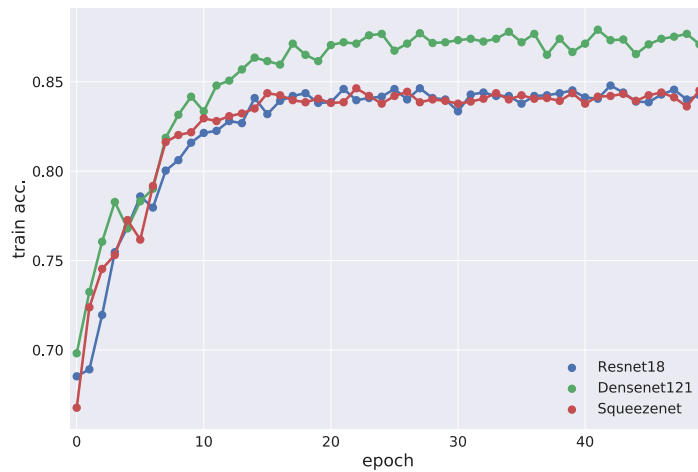
- current state of the art
- Densely connected convolutional layers
  - For each layer, feature maps of all preceding layers used as inputs
  - Designed for robust feature propagation
  - Apparent trend of using more connections between layers (RESNET)



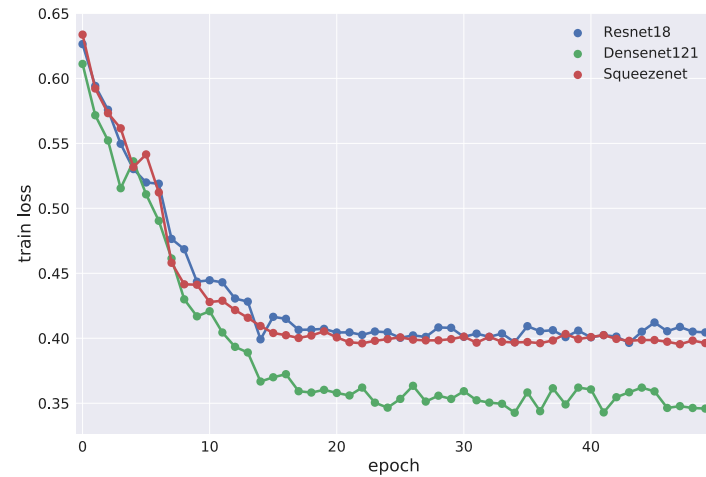
**Figure 1:** A 5-layer dense block with a growth rate of  $k = 4$ . Each layer takes all preceding feature-maps as input.

# ResNet, DenseNet, SqueezeNet Comparison (Training)

## Accuracy

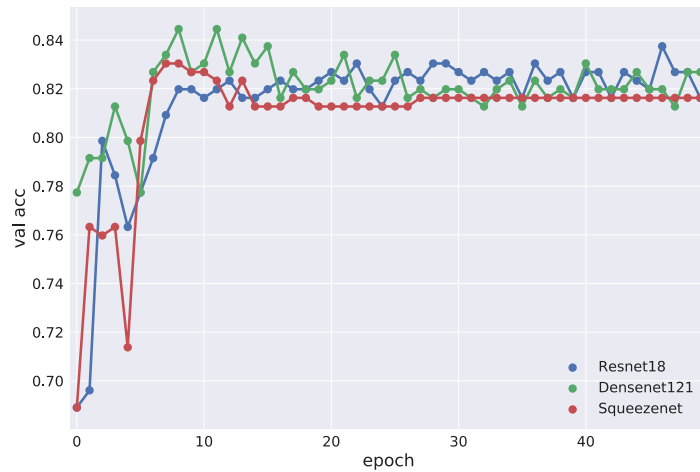


## Loss

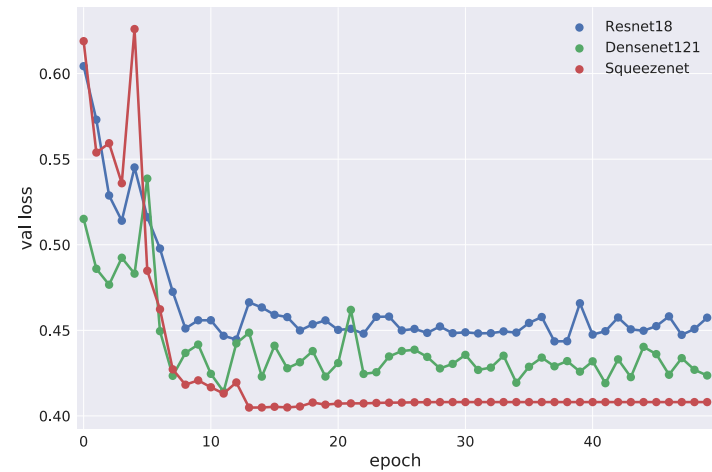


# ResNet, DenseNet, SqueezeNet Comparison (Validation)

## Accuracy



## Loss



# Conclusions and Future Work

- ICF Capsule data
  - Can be classified with an accuracy of ~83% (slightly better than a human operator)
  - Fairly subjective for certain classes of defects
- Next:
  - Classify the various defect types
  - Compare results with low precision networks
  - Leverage lessons learned to other projects

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# Thank You



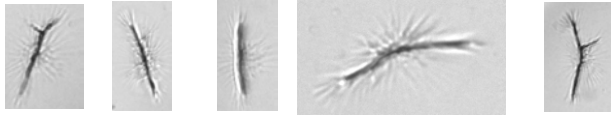
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# Additional Slides

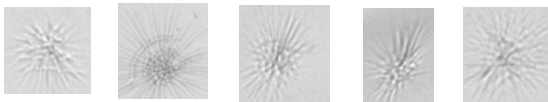


# Humans look for several different defects

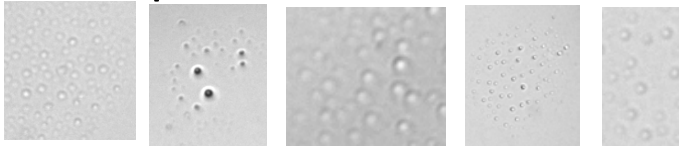
- Cracks



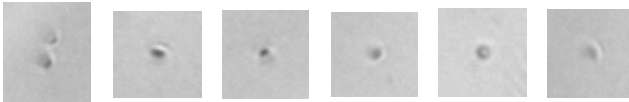
- Spider cracks



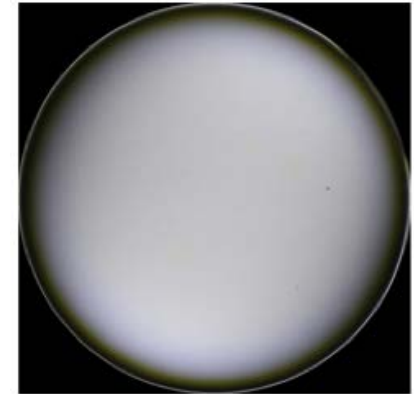
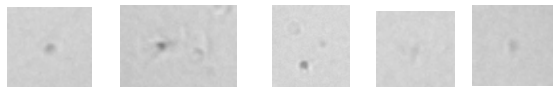
- Water spots



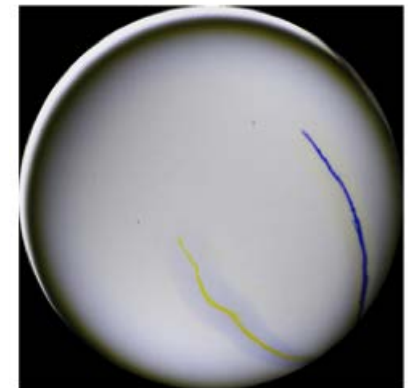
- Vacuoles



- Other



Good



Bad



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