



**Hewlett Packard**  
Enterprise

# **Machine Learning in The Chapel Programming Language**

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Iain Moncrief  
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## Background



Lightweight tensor and linear algebra library



TensorFlow

Extends NumPy to support ML needs  
(backpropagation, CUDA implementation)



Keras



Fully featured ML tools (uses TensorFlow)



# Chapel

- High performance computing
- Sophisticated array programming
- Automatically utilize maximal resources
- Easily program parallel computations



# My Project

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- Implement ML programs in Chapel
- See what aspects of Chapel make it easier/harder to implement ML programs
- Performance comparison



# My Chapel ML Implementation

- Tensor Library
  - Attempts to replicate much of NumPy's functionality
  - Arithmetic and linear algebra operations
  - Supporting helper functions
- Machine Learning Library
  - Implements various layer types: Dense, Conv2d, MaxPool, SoftMax, ReLU, TanH, Sigmoid, Flatten, ...
  - Offers similar user interface as PyTorch or Keras

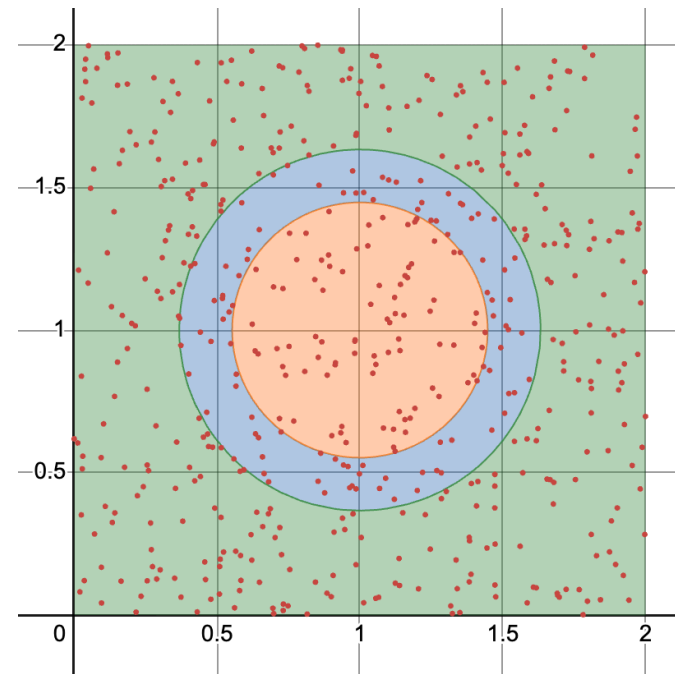
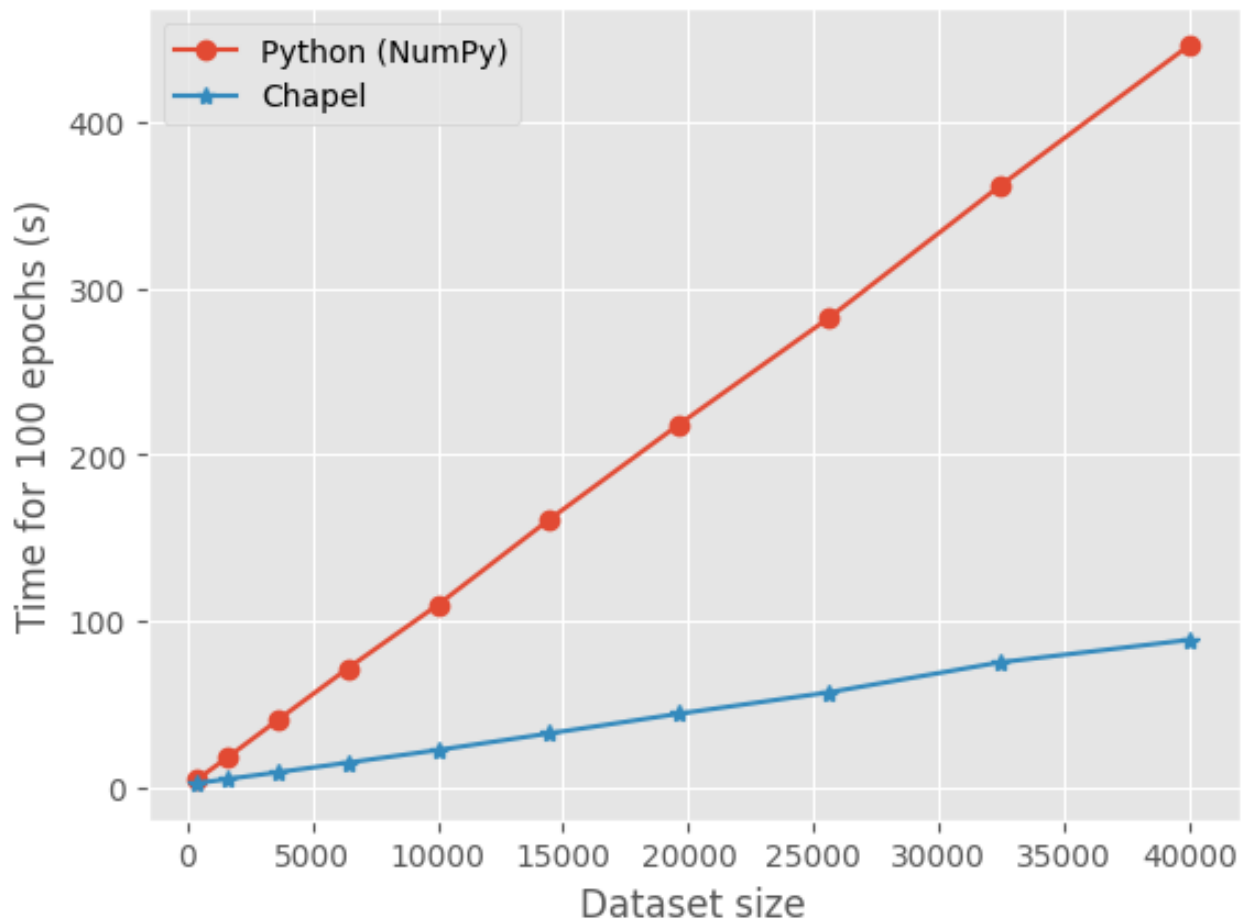
```
model = Sequential(  
    Dense(4),  
    Sigmoid(),  
    Dense(3),  
    Sigmoid(),  
)
```



```
var model = new Sequential(  
    new Dense(4),  
    new Sigmoid(),  
    new Dense(3),  
    new Sigmoid()  
);
```

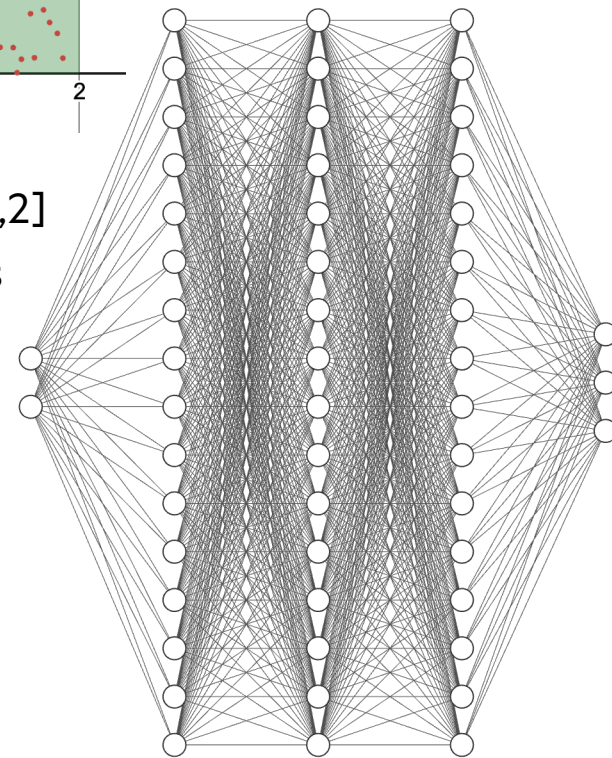


# Speed Comparison (Simple Classification)



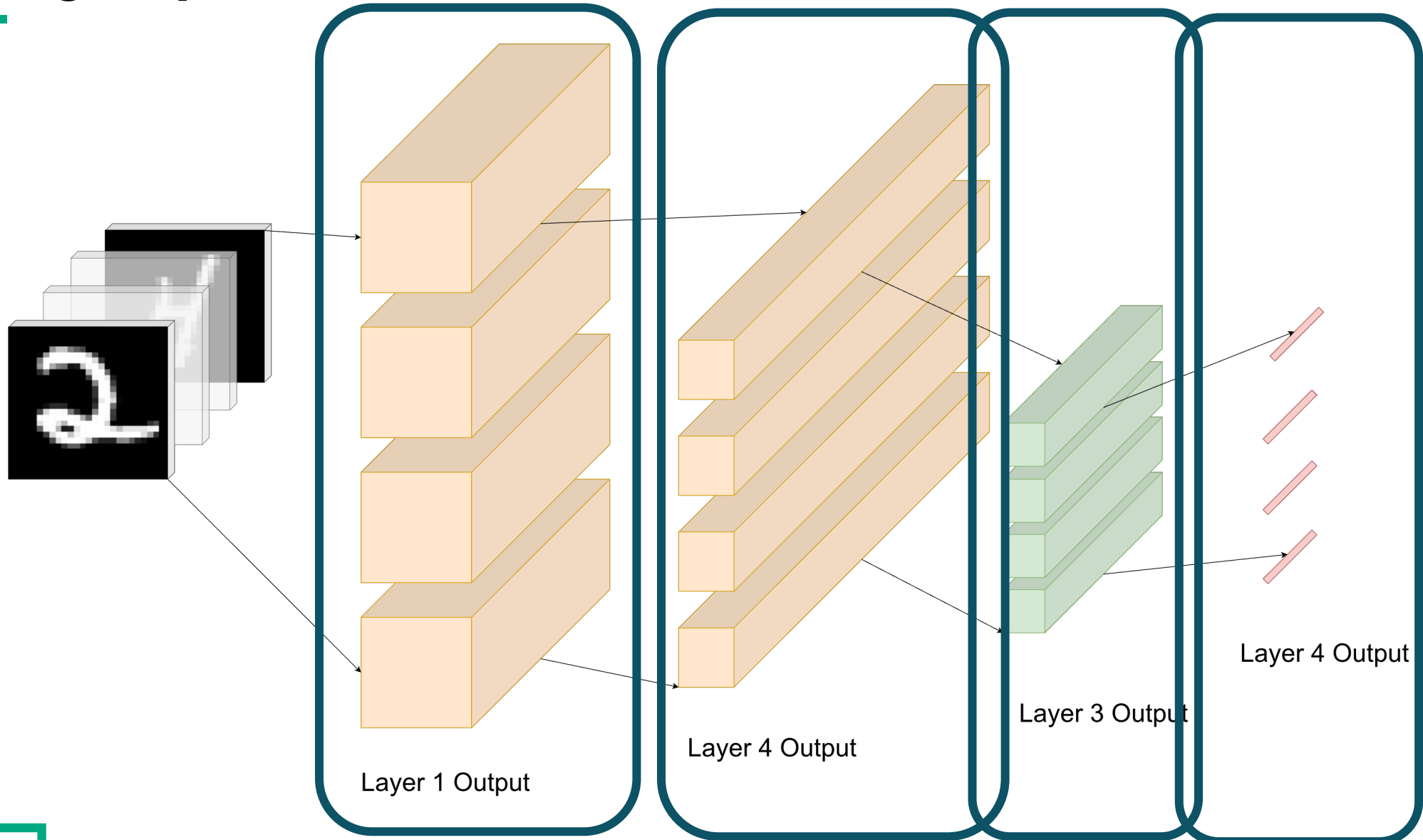
Input: N samples from  $[0,2] \times [0,2]$

Output: 3 different categories

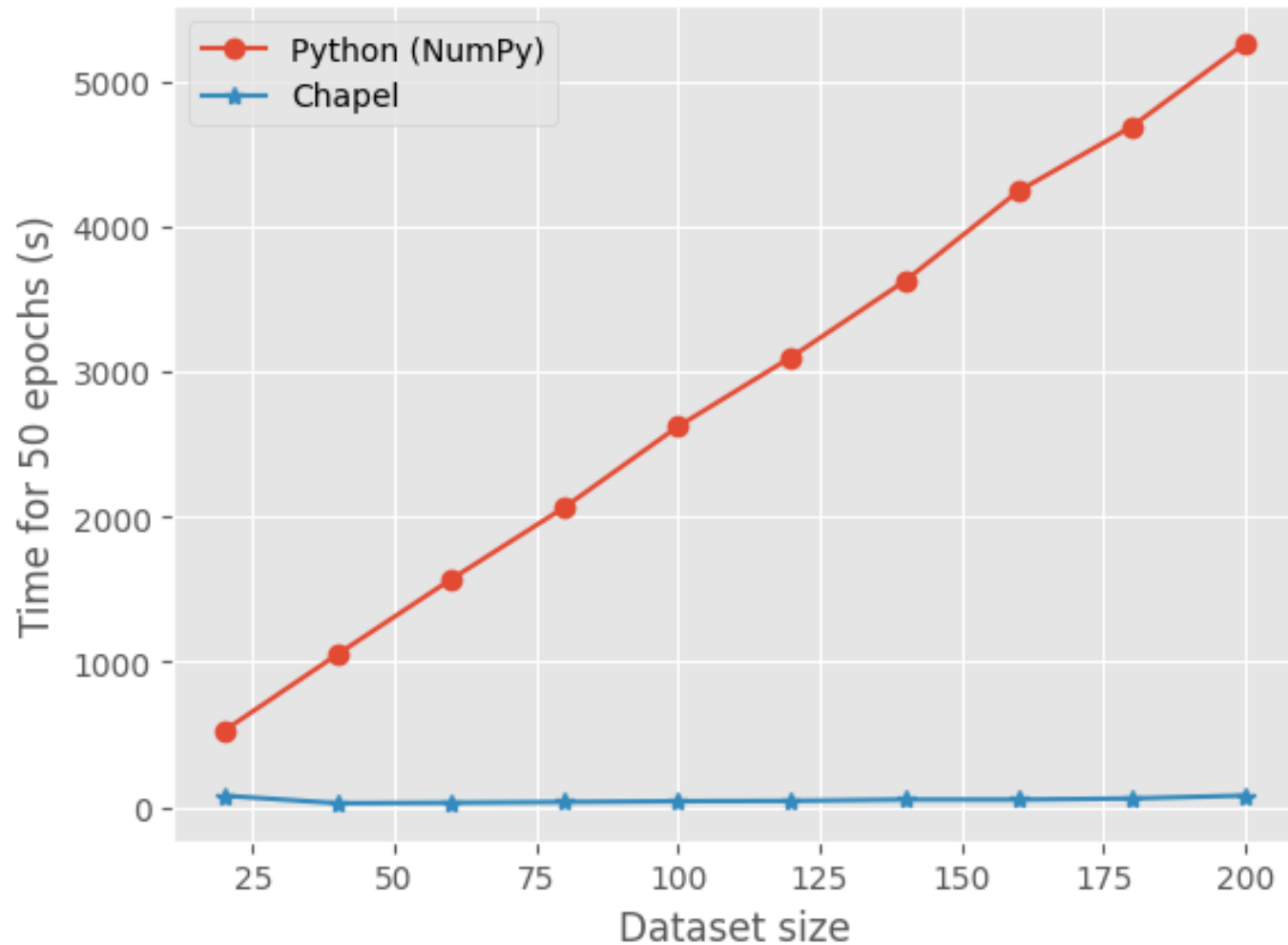


Input Layer  $\in \mathbb{R}^2$  Hidden Layer  $\in \mathbb{R}^{10}$  Hidden Layer  $\in \mathbb{R}^{10}$  Hidden Layer  $\in \mathbb{R}^{10}$  Output Layer  $\in \mathbb{R}^3$

# Utilizing Chapel's Parallelism Constructs



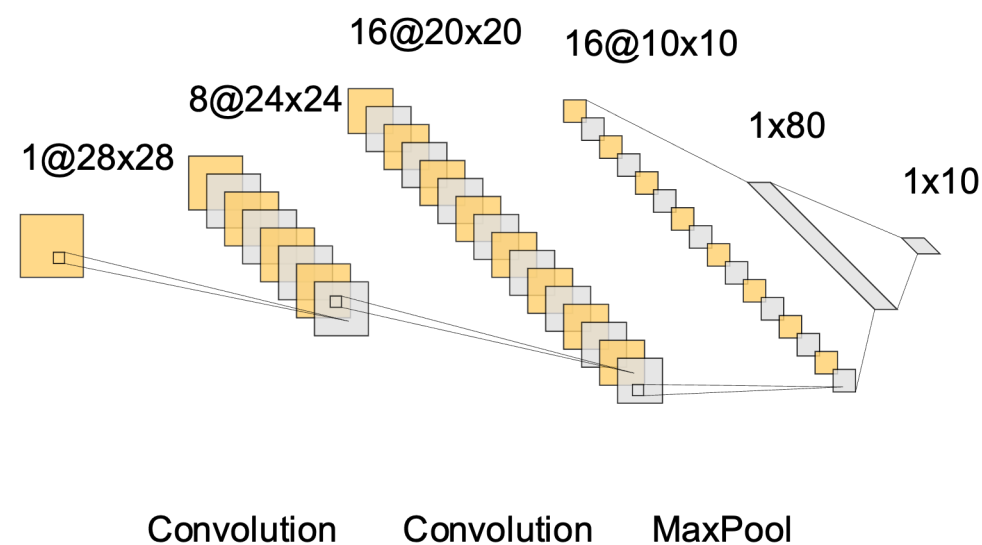
# Speed Comparison (MNIST Classification)



Input:



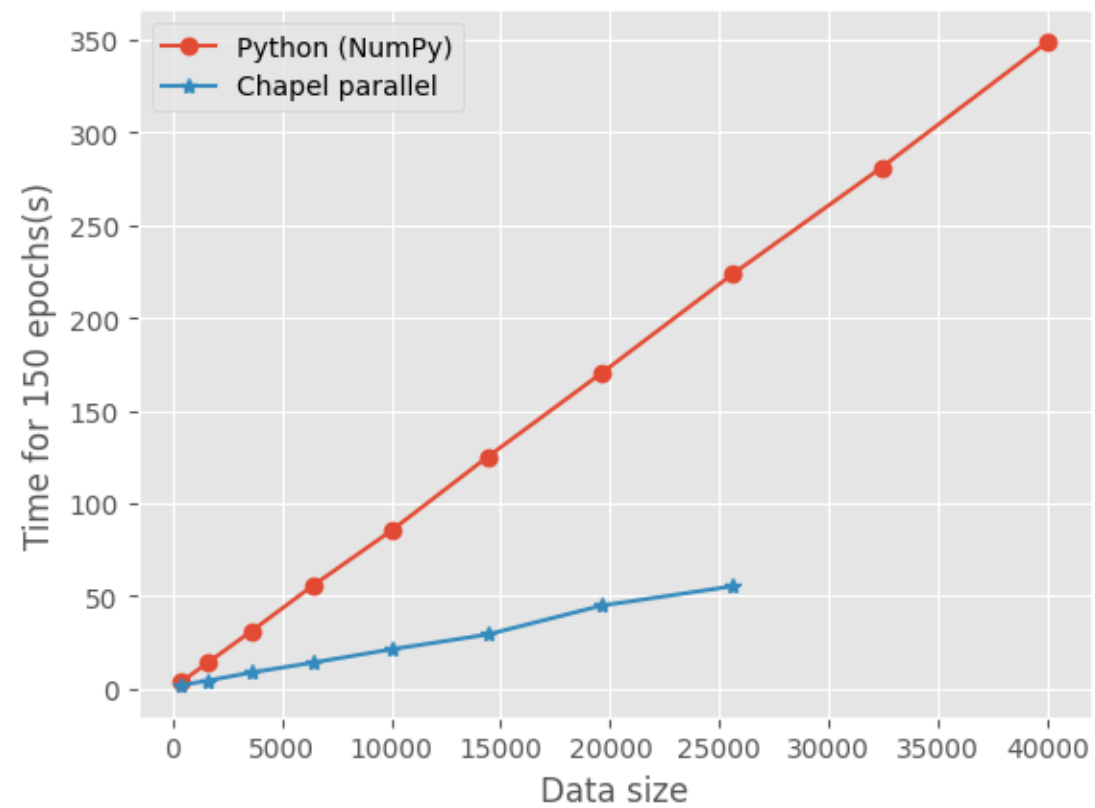
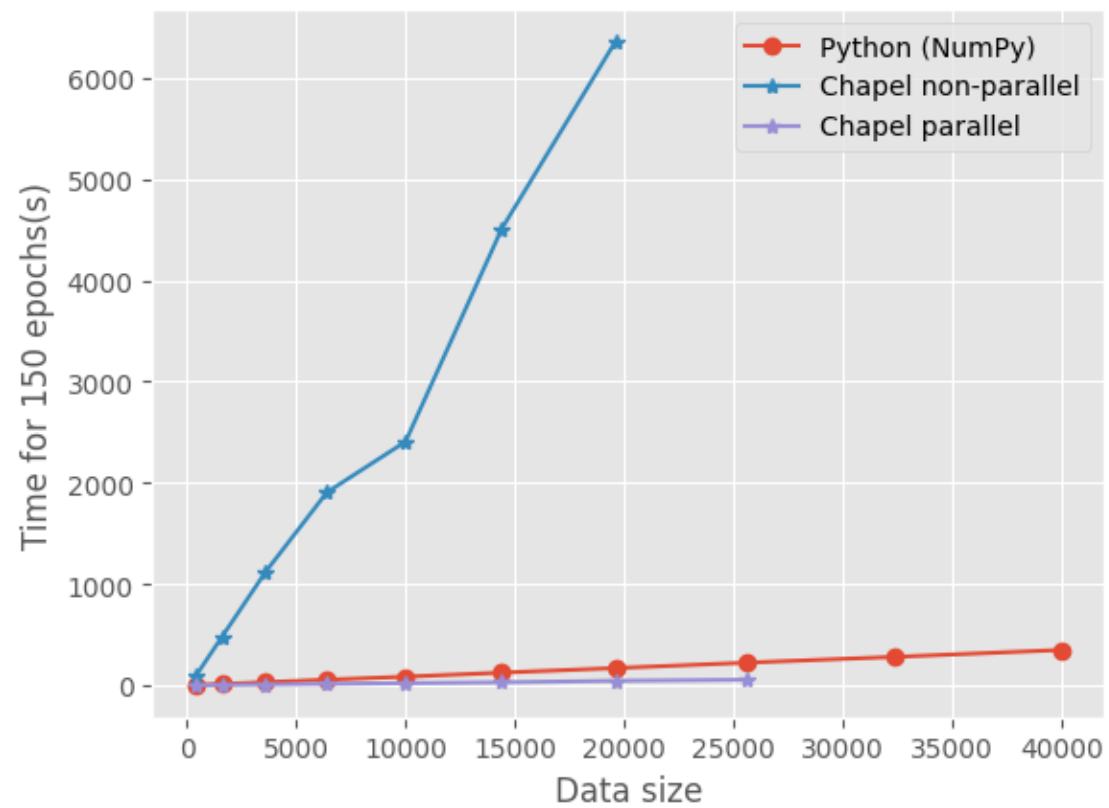
Output: 0,1,2,3,...,9





# Thank you





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