Handschrifterkennung mit CUDA und C++

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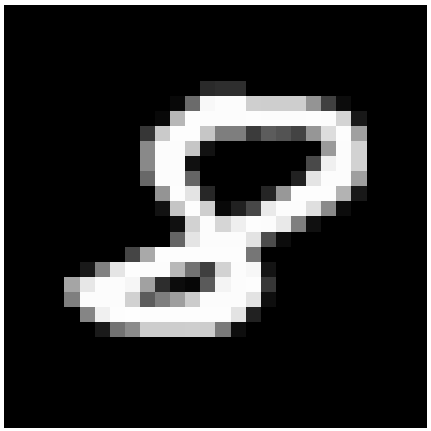
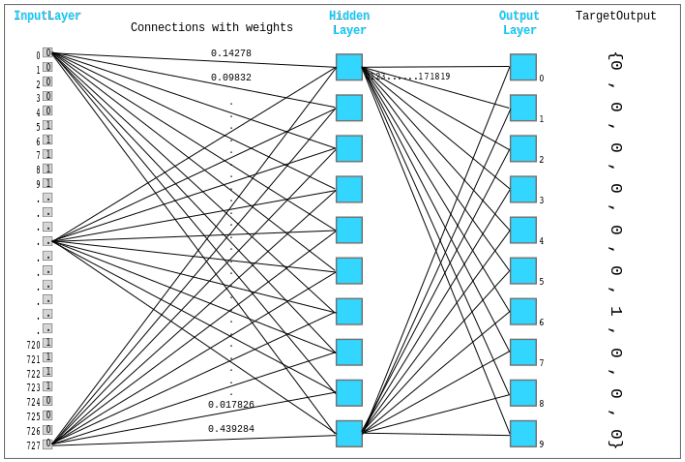
Aufgabe





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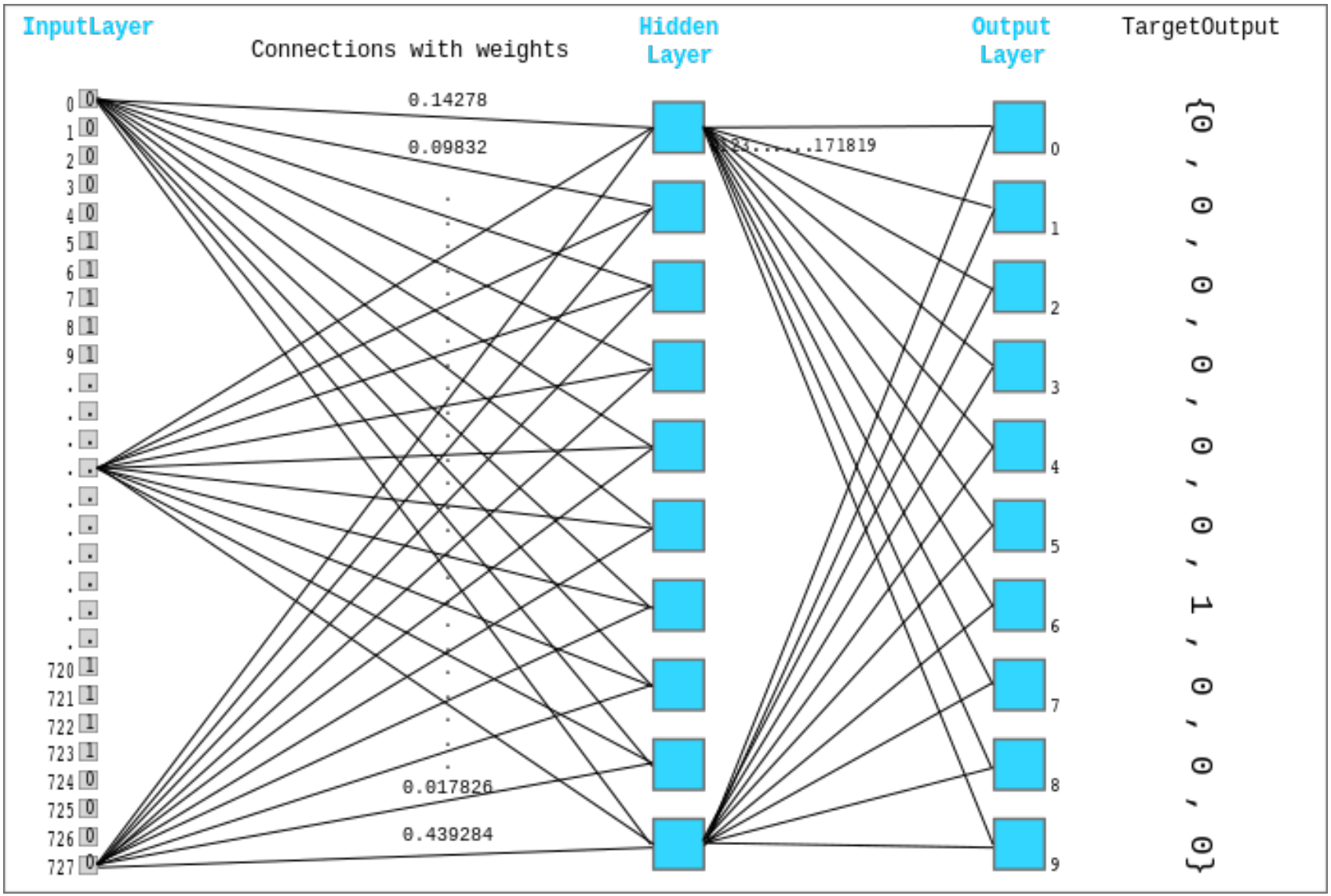
- Erkennung von handgeschriebenen Zahlen
- Neuronales Netz
- CUDA und C++

Training/Testing Dataset

THE MNIST DATABASE of handwritten digits

- 60.000 Trainings-Bilder
- 10.000 Test-Bilder
- Auflösung: 28x28
- IDX-Format
- Source: http://yann.lecun.com/exdb/mnist/

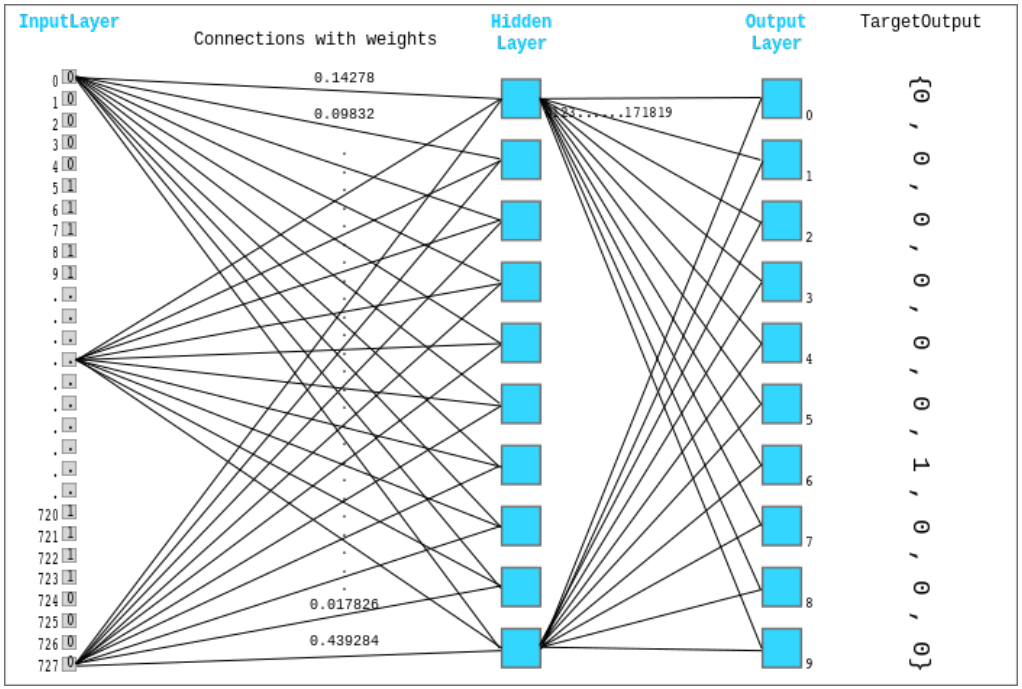
Feed-Forward / Back-Propagation



CUDA-Implementierung

Feed-Forward:

- Eingehende-Kanten (*edges*)
  - Thread
  - Berechnet Kanten-Wert
  - Speichert in *SharedMemory*
- Knoten (*nodes*)
  - Thread-Block
  - Summiert alle Kanten-Werte
  - Berechnet Knoten-Wert (Sigmoid)
- Ausgabe
  - Index des höhsten Knoten im *OutputLayer*

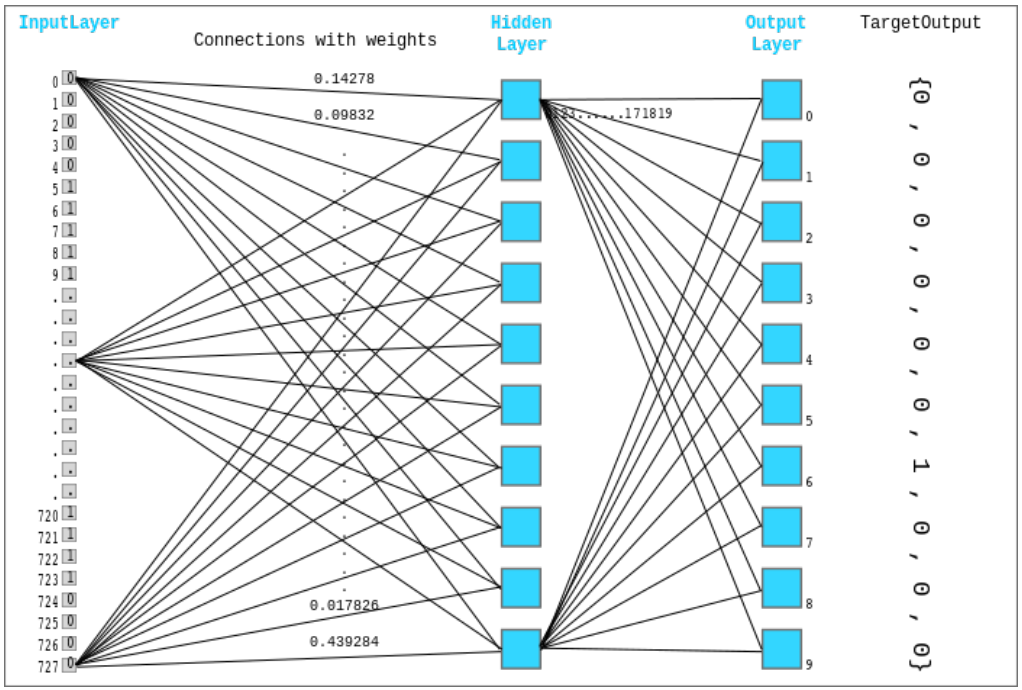


CUDA-Implementierung

Universität Augsburg University

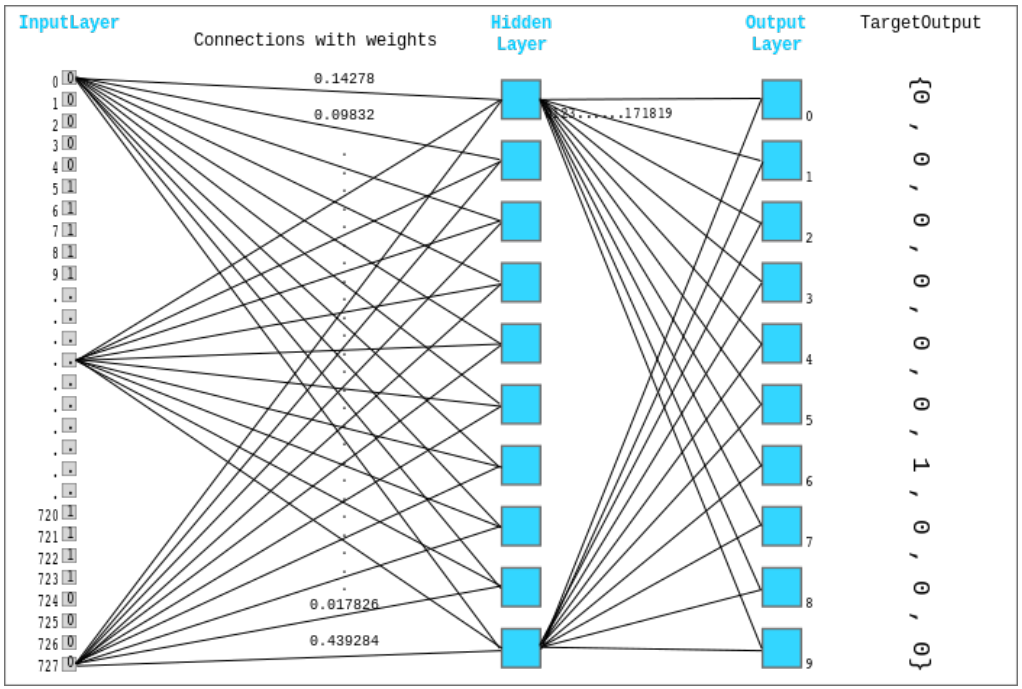
Back-Propagation:

- Ausgehende-Kanten (edges)
  - Thread
  - Berechnet Kanten-Fehler
  - Speichert in *SharedMemory*
  - Aktualisiert Kanten-Gewichte
- Knoten (nodes)
  - Thread-Block
  - Summiert alle Kanten-Fehler
  - Berechnet Knoten-Fehler



C++-Implementierung

- Aufteilung der Knoten auf n Threads
- Jeder Thread berechnet k Knoten-Werte/-Fehler
- Bulk-Synchronisation zwischen den Ebenen



Auswertung: Testsysteme

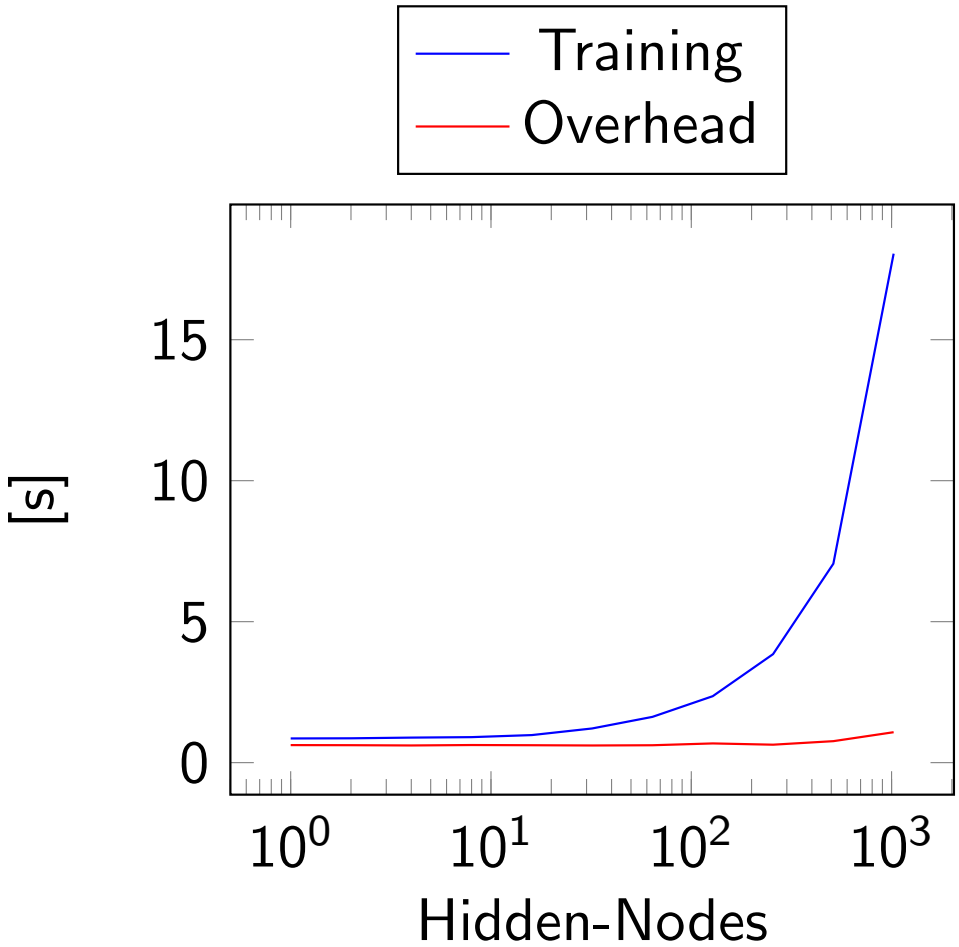
C++:

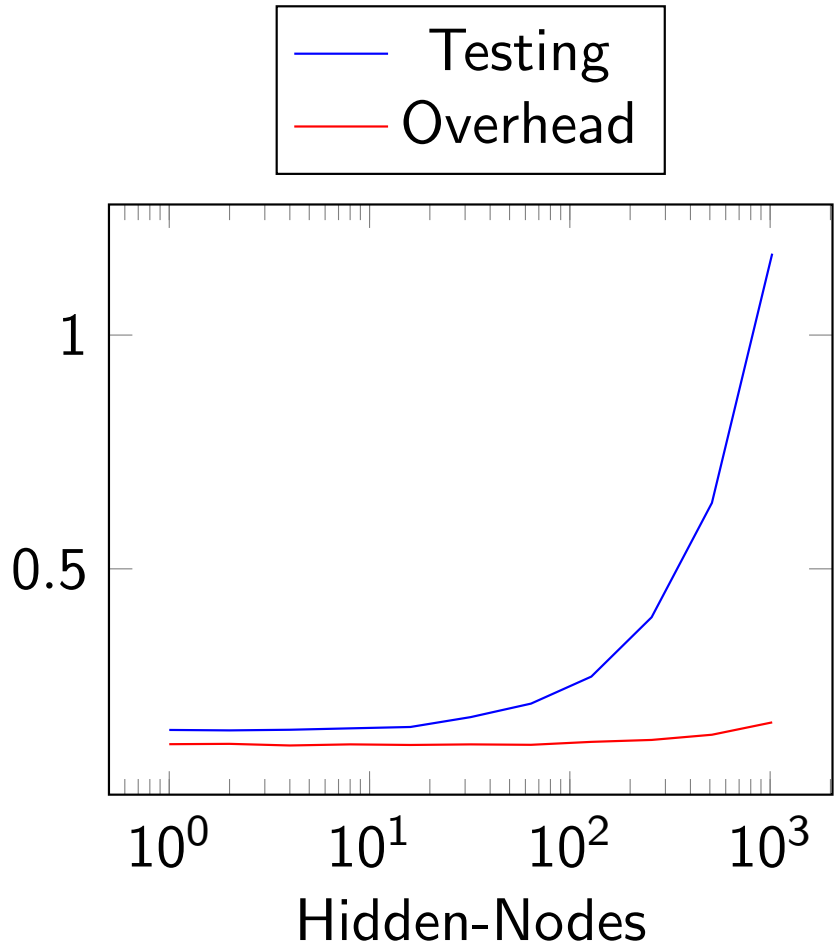
- Intel Haswell Core i7-4770 CPU @ 3.40GHz (8 *cores*)
- Ubuntu 17.04

CUDA:

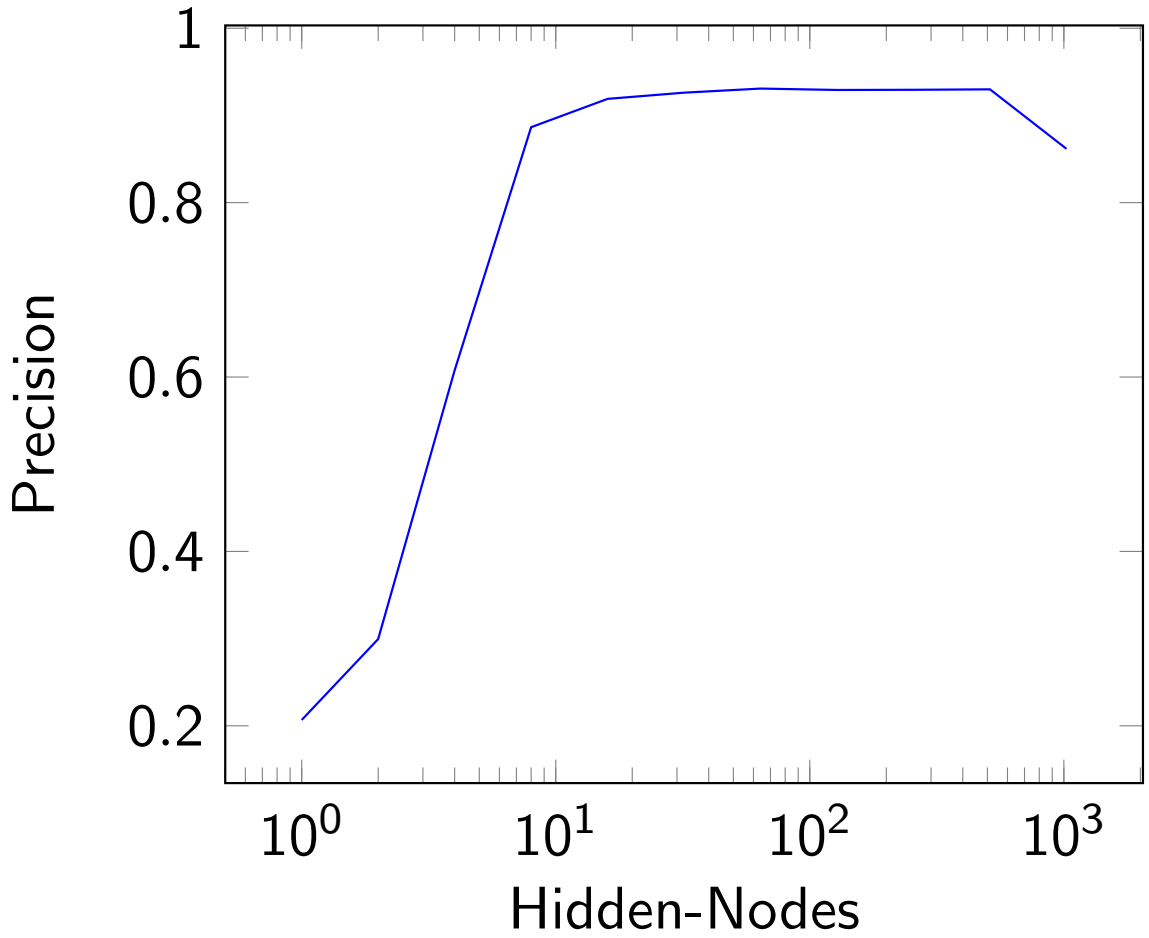
- Intel Skylake Core i5-6600 CPU @ 3.30GHz (4 *cores*)
- Nvidia Pascal GTX 1070 @ 1.607 GHz (1920 *cores*)
- Ubuntu 17.04

Auswertung: CUDA

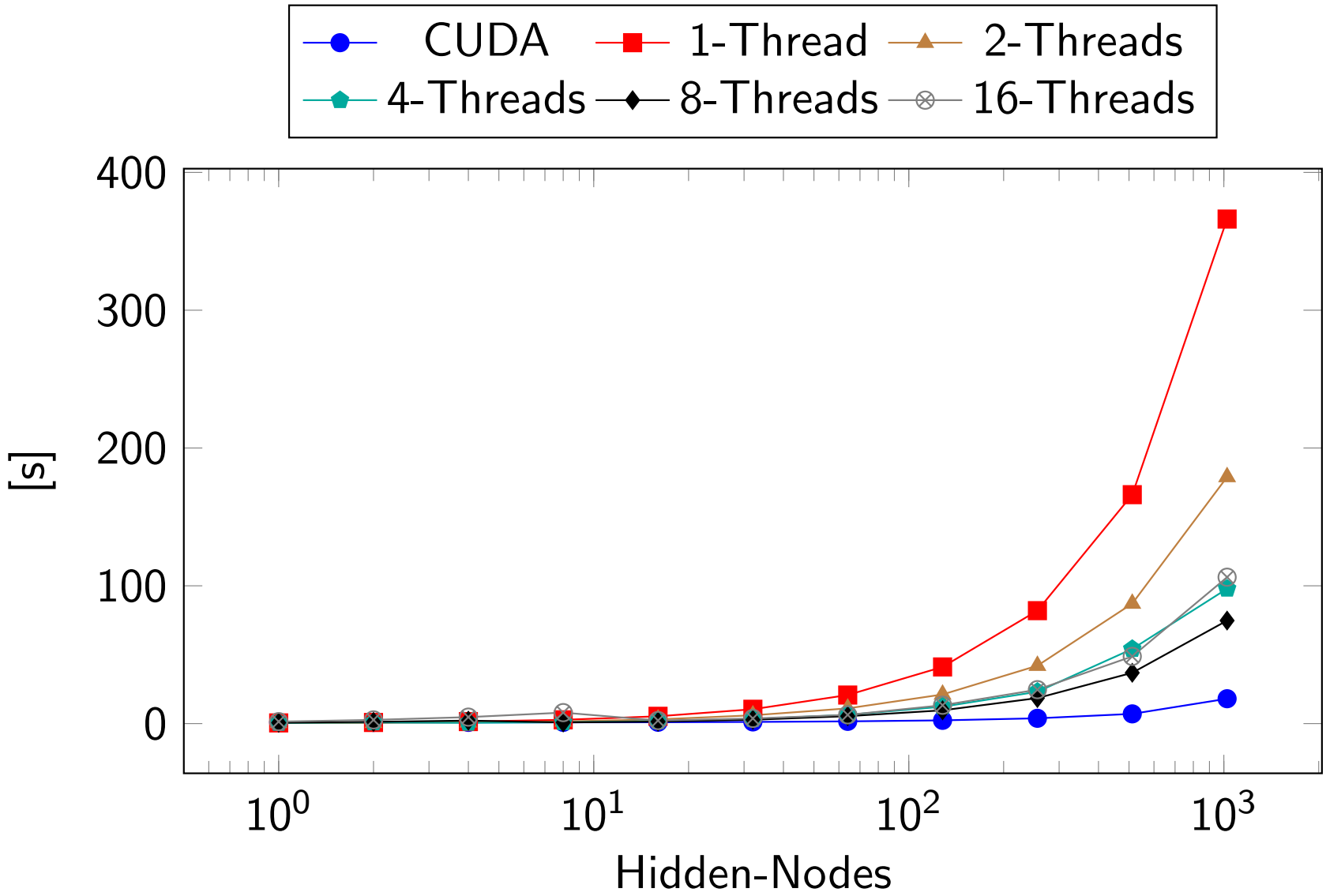




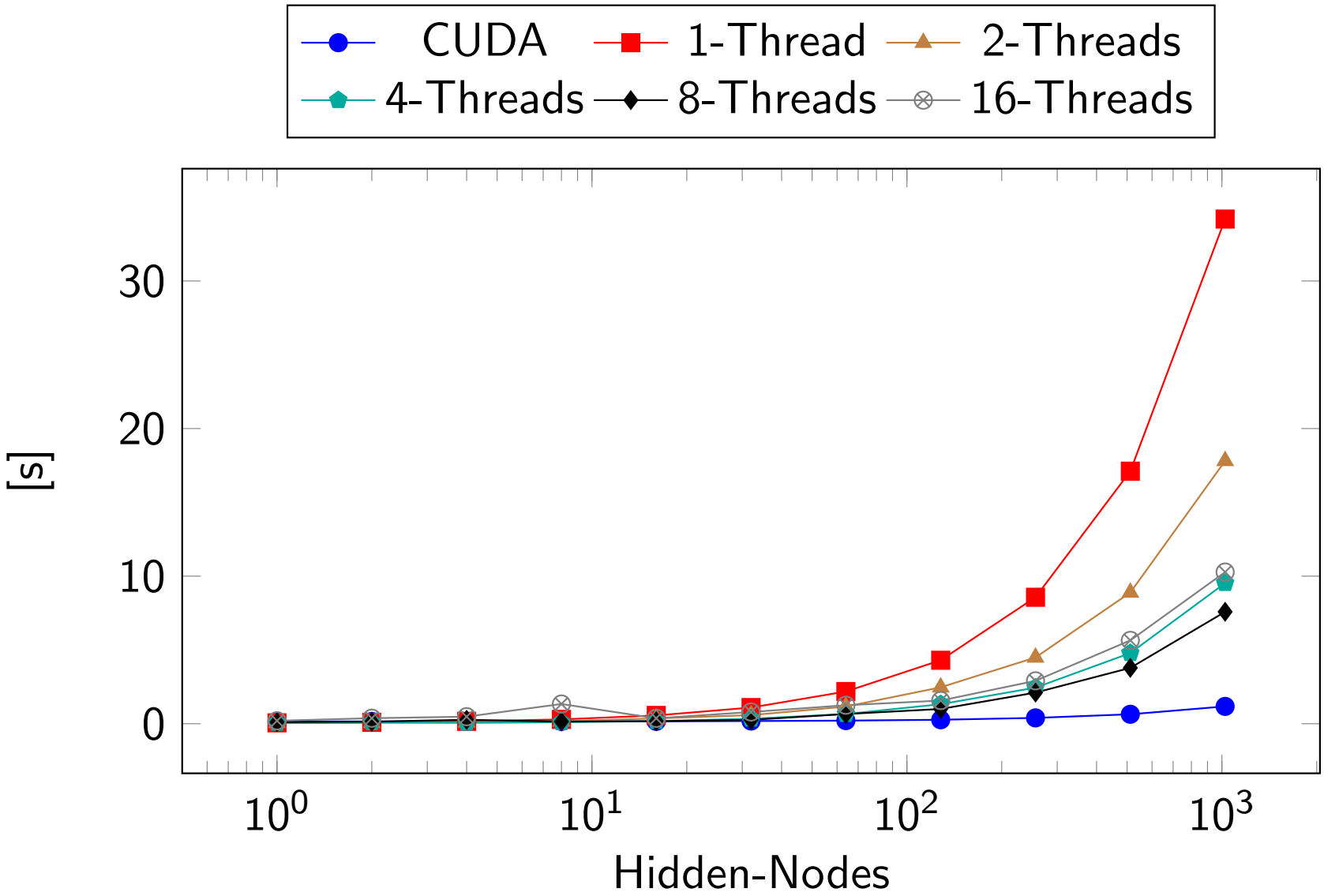
Auswertung: Precision



Auswertung: Training



Auswertung: Testing



Auswertung: Ergebnis

CUDA / C++:

- 3-layer NN 784-256-10
- Precision: 98.03%
- Dauer des Trainings (30x):
  - CUDA: 111.789sec
  - C++: 545.011sec
- Dauer des Tests:
  - CUDA: 0.40289sec
  - C++: 1.91795sec

Deep Big Simple Neural Nets Excel on Handwritten Digit Recognition (2010):

- 6-layer NN 784-2500-2000-1500-1000-500-10
- Precision: 99.65%

Auswertung: Fazit

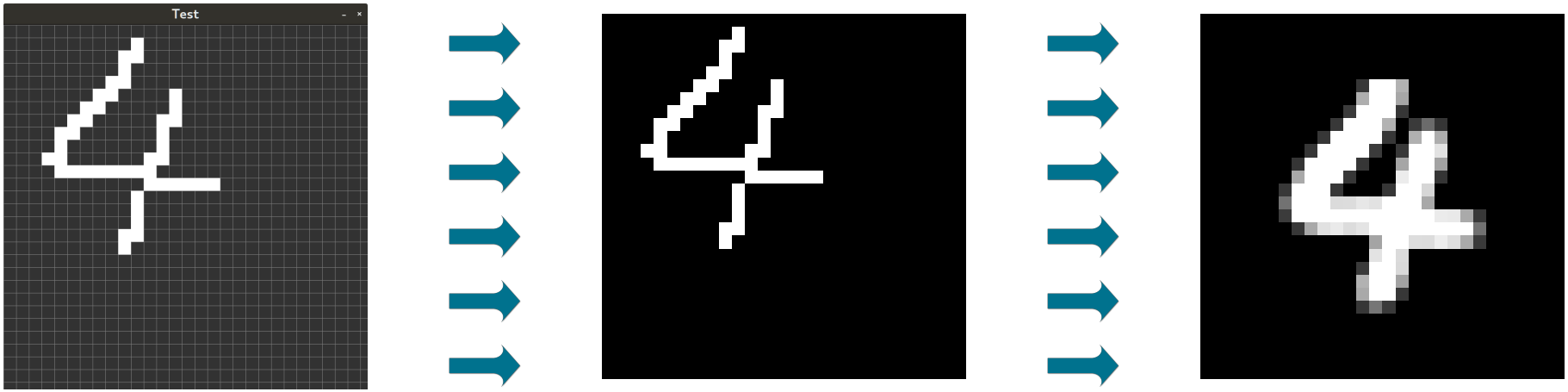
C++:

- Synchronisierungsoverhead
- Limitiert durch die Anzahl der CPU-Kerne
- Auseinanderlaufende Threads beschränken die Parallelität
- Fehlende Vektorisierung?

CUDA:

- Zu viele *Kernel*-Aufrufe
- Zu geringer *Workload*
- Datenübertragung
- Viele Speicherzugriffe

Demo



- GUI-Fenster zum Zeichnen
- Eingabe 1:1 in Bild umwandeln
- Normalisierung