Analysis and Simulation on Coarse-Grained A/D Conversion Circuit

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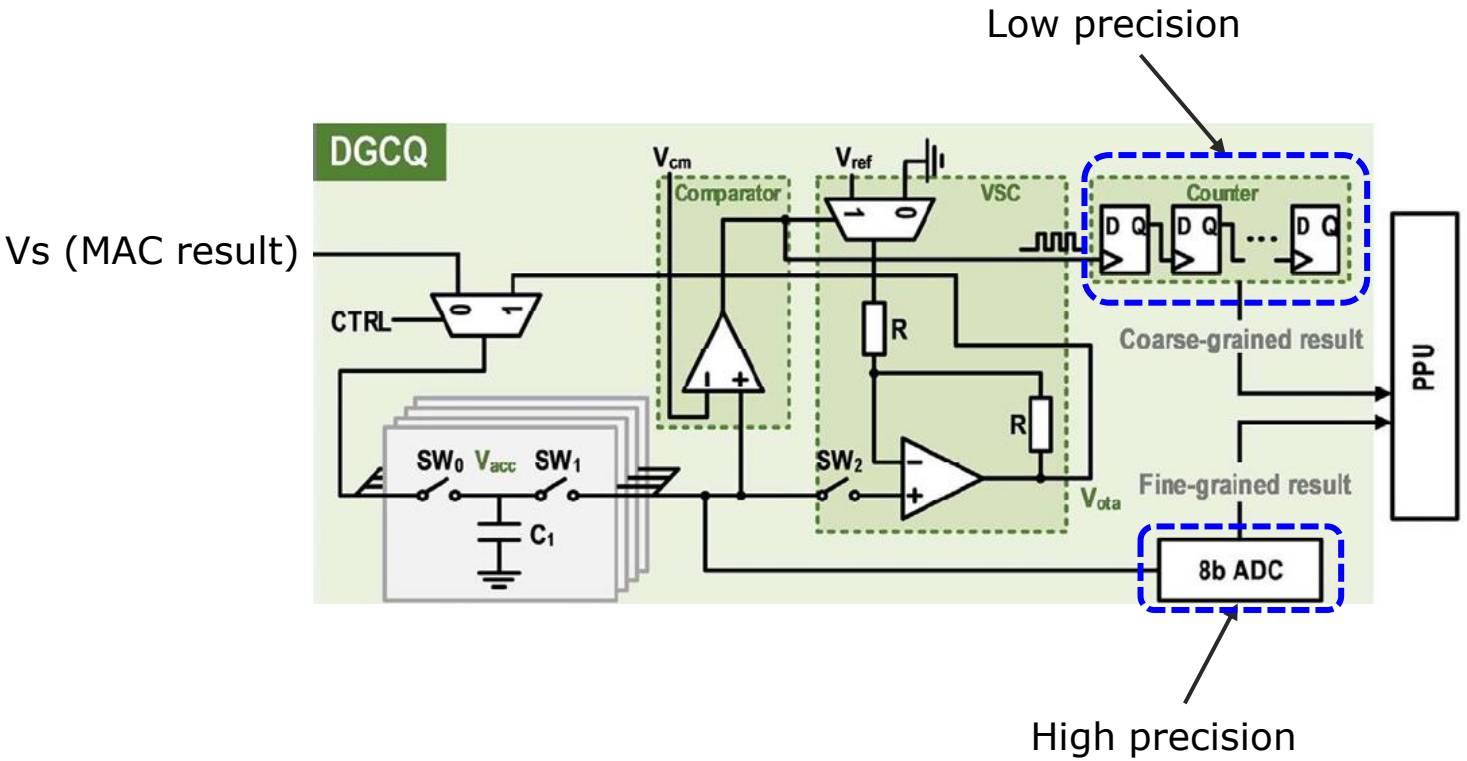
Recall

- Dual-granularity cooperative quantizer
  - When quantizing analog voltage, use another ckt to calculate an approximated result



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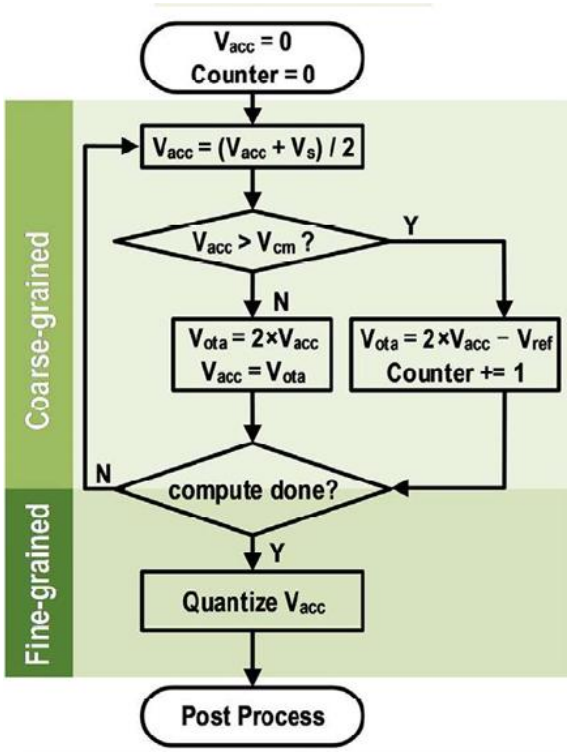
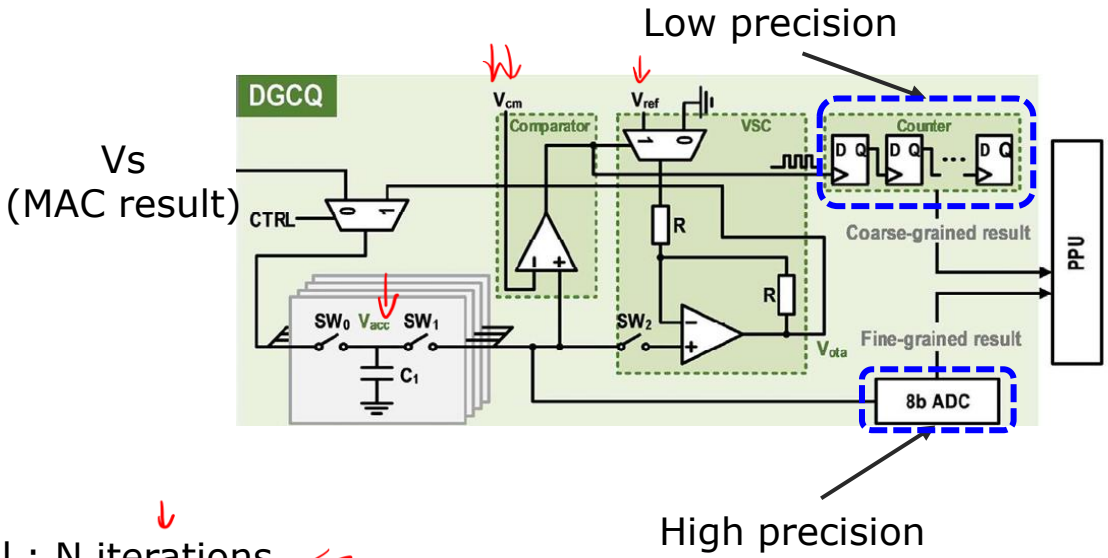




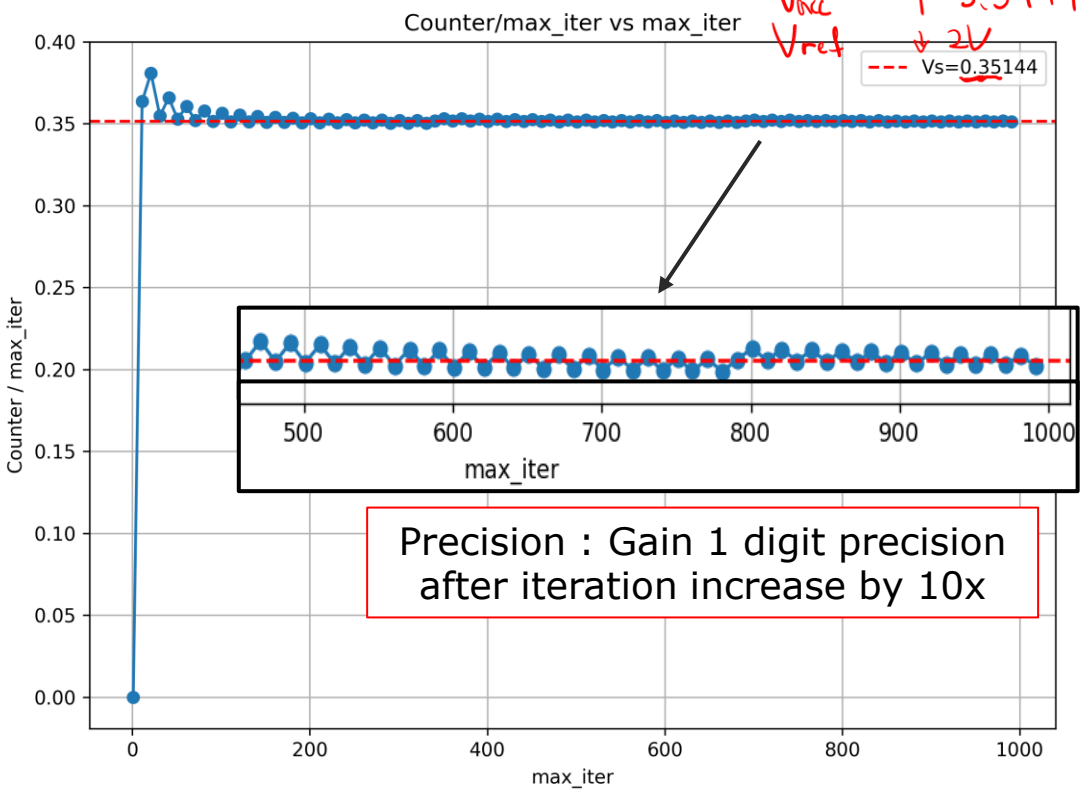
Total : N iterations

Total V : N · (Vs/2)

Counter : N · (Vs/2) / Vref

Effect of Iteration & Vcm & Vref

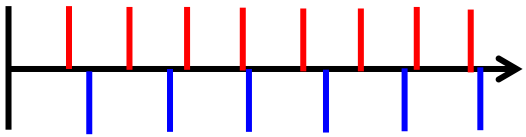
- Iteration
  - Quantization result converges after 200 cycles
  - Remainder cannot -> 0 after many iterations



Precision : Gain 1 digit precision after iteration increase by 10x

V_{inc} + 3.5144 V − 3 = 0.5144 V Counter = 3 $\frac{3 \times 2}{20} = 0.3$

V_{ref} + 2V



Red : $\text{iter} \cdot \frac{V_s}{2}$

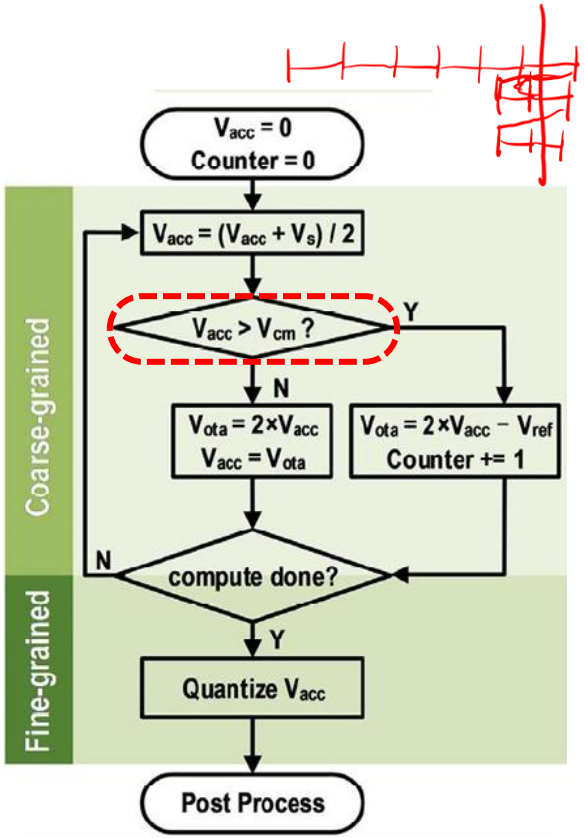
Blue: $N \cdot \frac{V_{ref}}{2}$

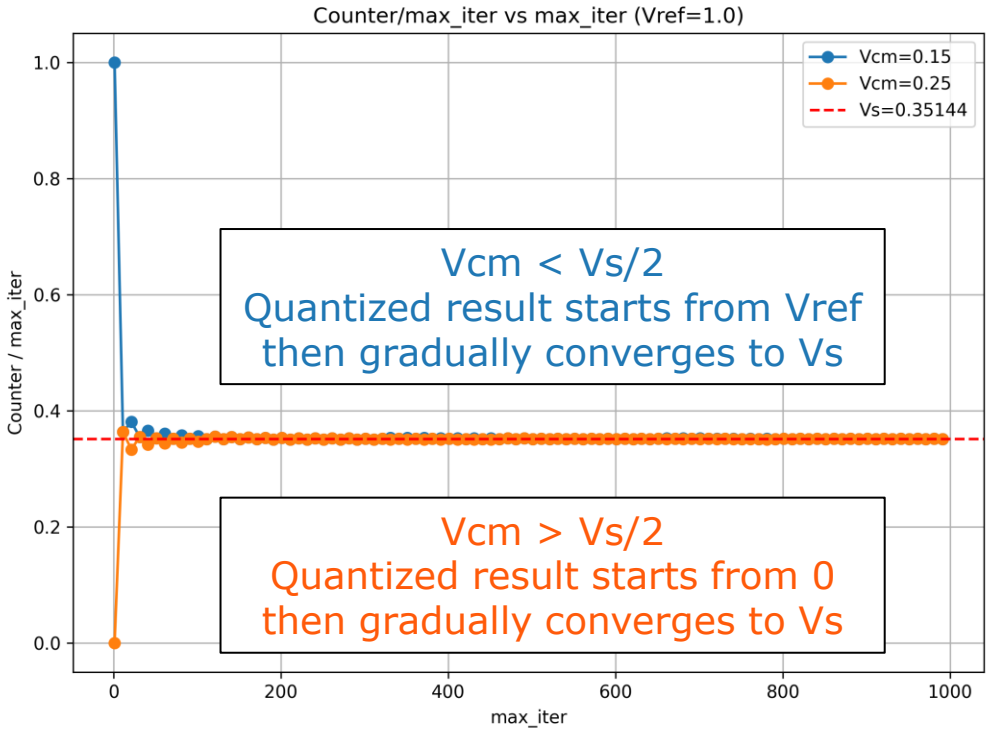
Precision : Gain 1b precision after iteration x 2

Precision cannot infinitely grow as a trade-off of latency + throughput

Effect of Iteration & Vcm & Vref

- Vcm
  - Vcm has slight effect in this quantization method, as it is a threshold of Vacc to start calculating

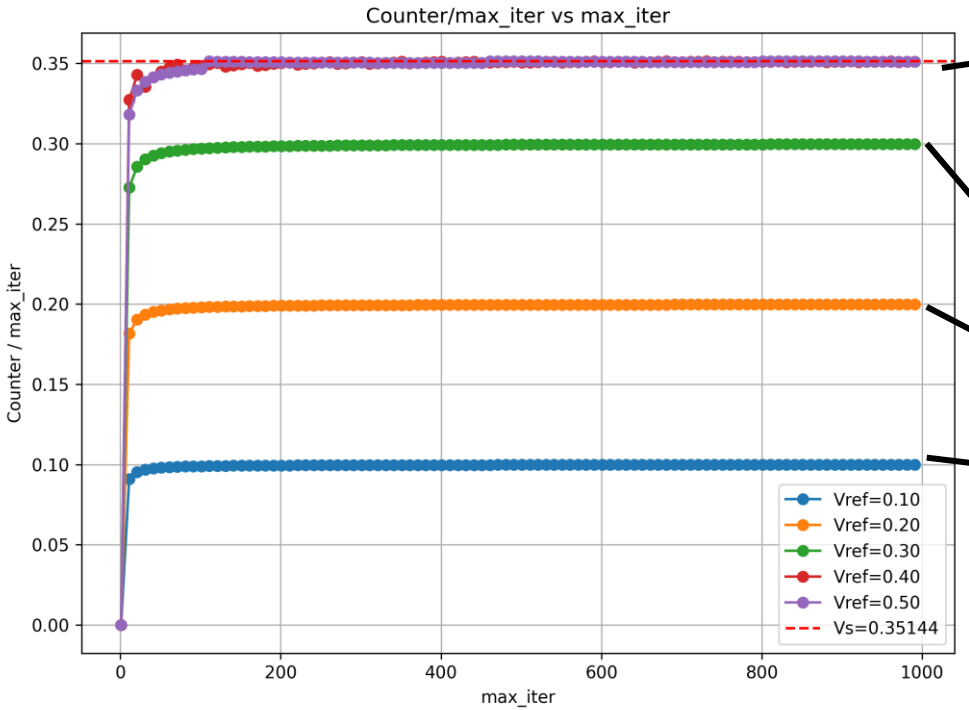




Effect of Iteration & Vcm & Vref

- Vref
  - Vref has to be larger than all possible Vs to quantize
  - Small Vref will lead to wrong quantization result

$+\frac{Vs}{2}$ $-\frac{Vref}{2}$ V_{cm}



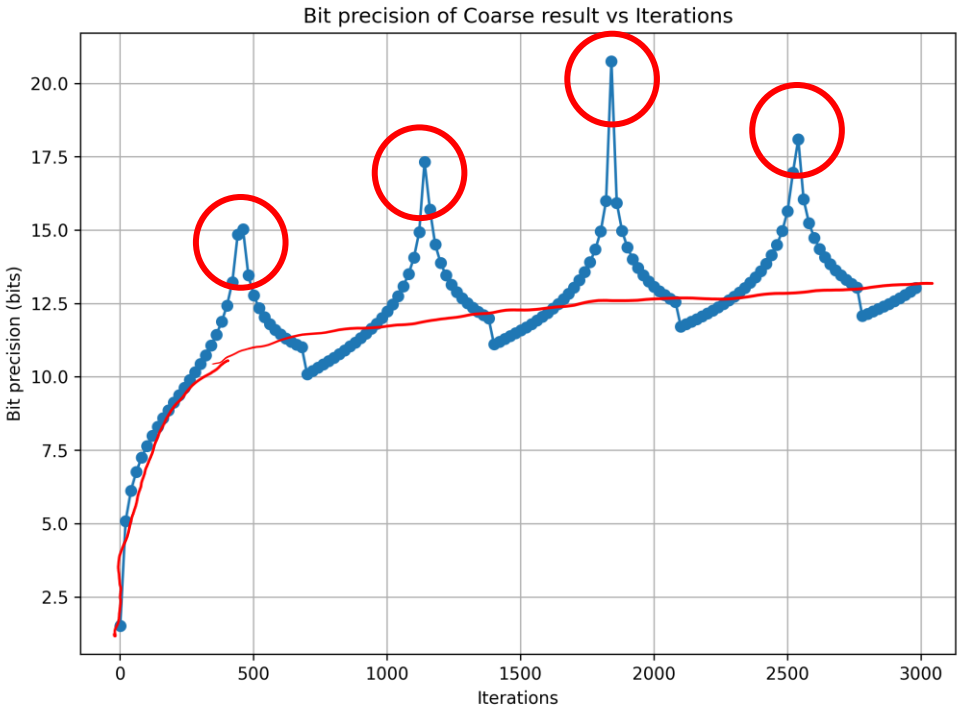
Vref > Vs
Quantized properly

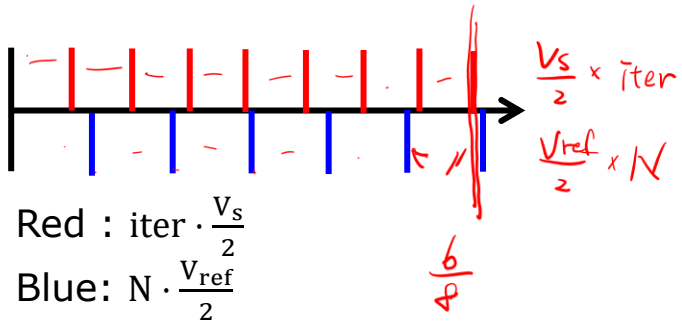
Vref < Vs
Converges to Vref rather than the result we want due to we only subtract Vref/2 every cycle

+ Vs/2 – Vref/2 per cycle

Bit Precision of Coarse-Grained Value

- Bit-precision
  - Bit-precision generally exhibits a logarithmic growth trend, but superimposed with local periodic variations.





OUT precision : 21 bit
Coarse-grained : roughly 13 bit

Impact of Poor Precision on ML Tasks

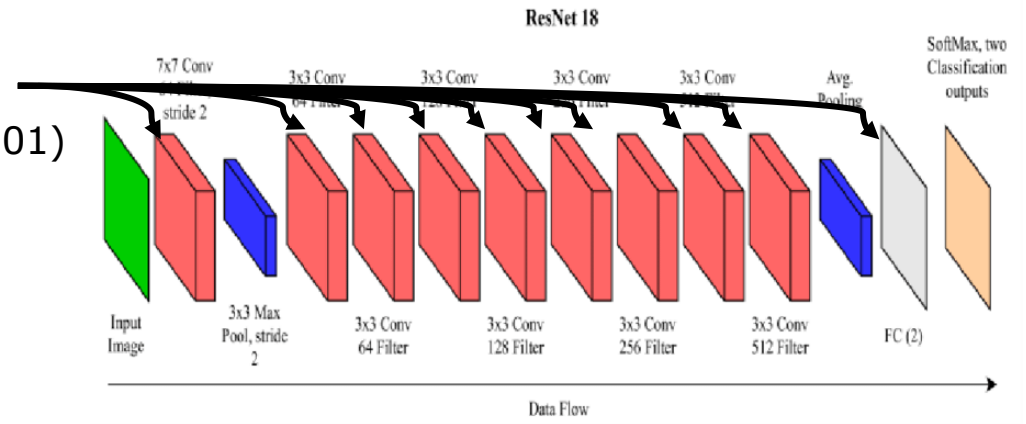
- The dataset used in the paper is ImageNet
  - ImageNet is not implemented in torch
  - Use a simpler dataset CIFAR-10

Model	ResNet-18
Dataset	ImageNet
Data precision	INT8
Task	Classification
Metric	Accuracy

- ResNet-18
  - Trained using fp precision
  - Quantize to int8 after training
  - Compute MAC result for each layer and apply loss

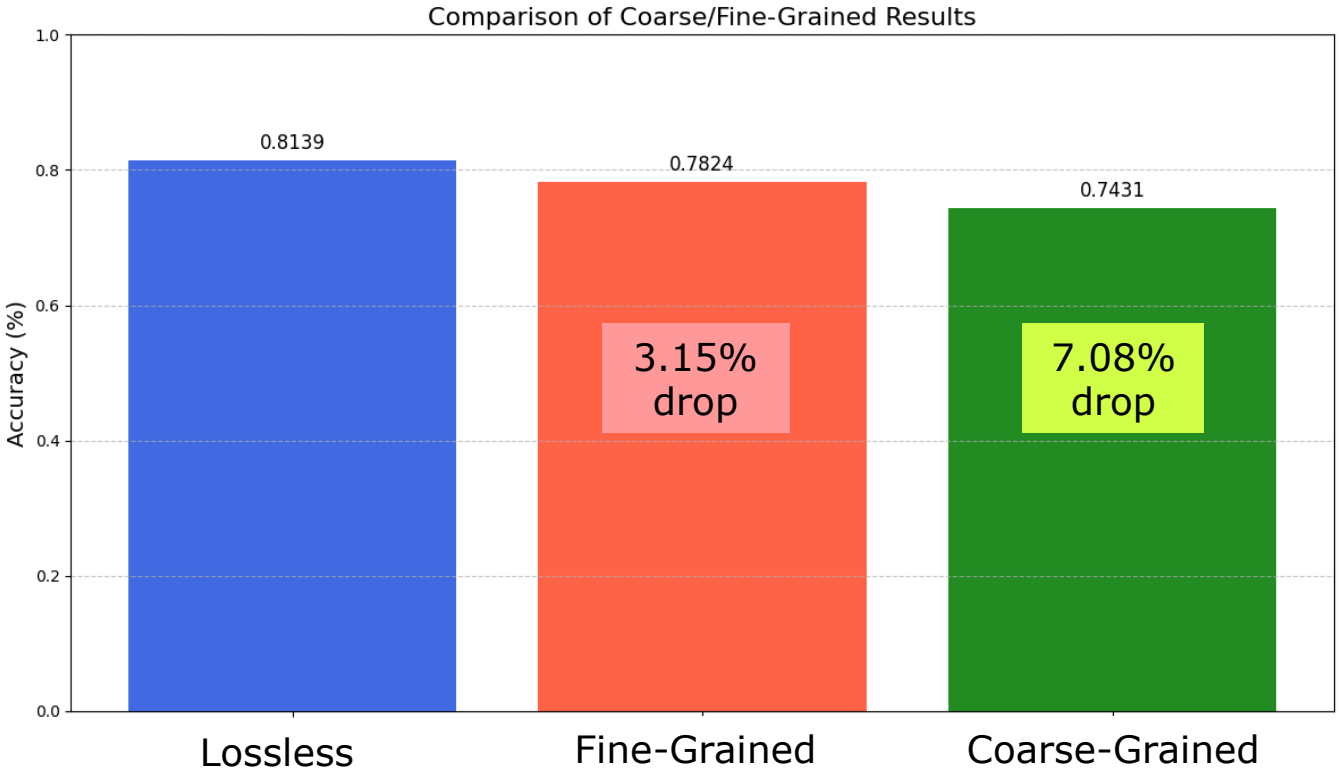
-LOSS

Gaussian(-Loss,0.01)



Impact of Poor Precision on ML Tasks

- Comparison between coarse/fine-grained value



DGCQ : Merge 2 types of granularity