A picture is worth 1000 features!

Using **computer vision** alongside **machine learning** in computer systems.

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We make graphs for system and paper evaluation.

We look at graphs to understand system behaviors.
My Relationship with Visualization

Spent years staring at these images.

**Topic:** Machine Learning for Memory Management Systems*

I visualized “memory access patterns” to explain system behaviors across application domains.

The key insights of my systems designs came from *visual* observations!

My papers: “Cori” at IPDPS 2022 and “Coeus” at CCGrid 2022.

Visualizing Data Access Patterns

Let’s create images for larger workloads.

Spec17.612.wrf  Spec06.450.soplex  Spec06.437.leslie3d  Spec06.473.astar  Spec06.473.astar (larger input)

Challenge: limited 2D space to depict millions of data points.

Let’s zoom-in until we see clear lines.

Open Problems:
• Make 1 image and then zoom in?
• Make many images from start?
• Time window per image?
• Image resolution / size / color?
• Metadata?
  Benchmark, level of mem/cache, etc..
Computer Vision + Machine Learning for Systems Learning data access patterns.

What can an image-based system pipeline look like?

Pattern Recognition

After solving the visualization challenges described above..

..Can we build an “ImageNet”, a public image dataset of data access patterns?

Open Problems:
- What classes to define?
- Labeling guidelines?
- Community Contributions?
- Train classifiers for pattern recognition?
- Impact of misclassification?
- OS/Library/Compiler/Runtime support for pattern detection?

Challenge: how to properly label data access patterns?
Pattern Prediction

As the workload is running, the Operating System (OS) is “watching” a video of how the application accesses data.

Open Problems:
- Which one is “best”:
  - CV + ML vs. ML vs. non ML.
  - Accuracy, training times, misprediction impact.
- 1 model for all, per app, per pattern?
- Training intervals vs. OS operation.

We can leverage machine learning methods for predicting the next frame of a video.
Other Use Cases of Computer Vision in Operating Systems

Forecasting any type of time series data: e.g., server / cloud / application resource usage over time.

Open Problems:
• How many timesteps per image?
• Similar visualization and labeling challenges as above.

In the financial domain learning images lead to higher accuracy.
From OSDI ‘21 Keynote from J.P. Morgan AI labs.
Why Images?

Let’s rethink how we represent data for machine learning.

Creating images helps:

- Reduces dimensionality to a 2D space (3D if color).
- Captures spatial and temporal correlations.
- Reduces input space and training times e.g., 10000 raw values vs. 10x10 image.
- Leverage computer vision algorithms.

A picture is worth 1000.. Features!

Will it be more effective than ML or non ML solutions? Let’s see!

Just the insight of observing those images is beneficial for how we design systems.
I am proposing a new intersection of research areas, the **SysMLCV**.

Let’s work together!

Scan my website