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Recursive Sketches for Modular Deep Learning

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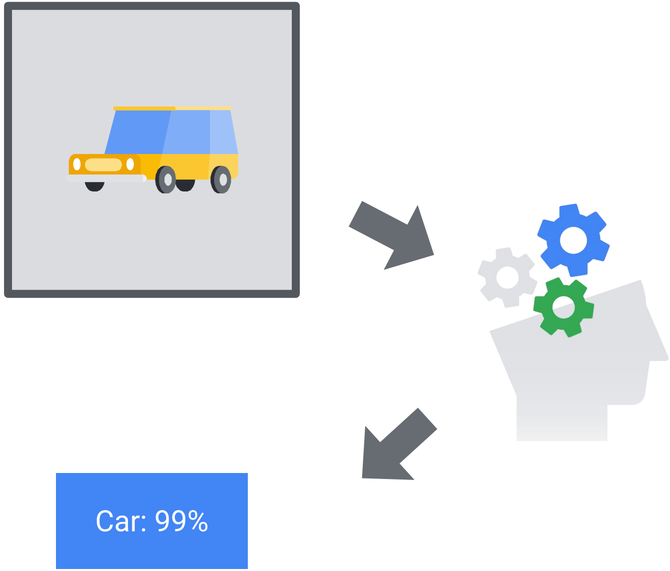
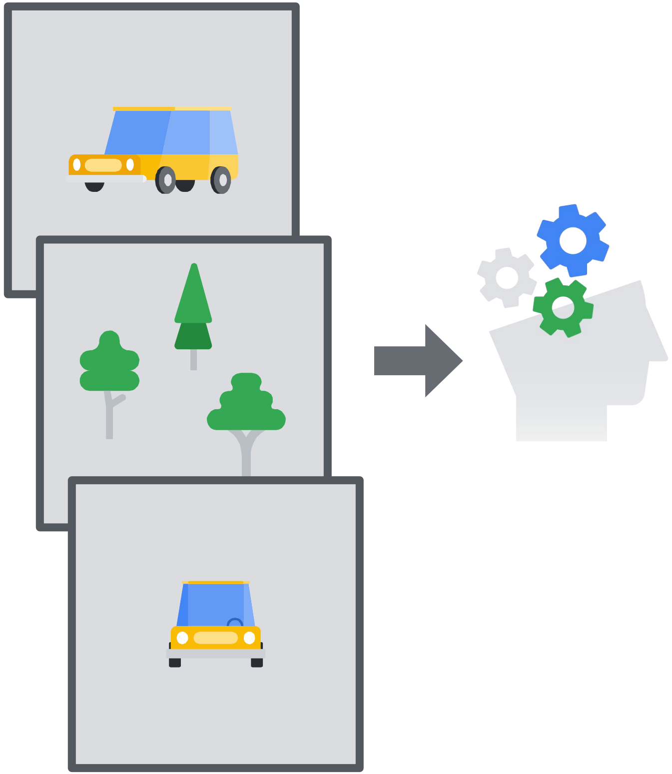
Object Recognition

- Rich literature around ML techniques for object recognition.
- Typical problem format.
  - Input: Picture
  - Output: Its object(s)



Object Memory

- This talk: twist on typical task.
  - Input: Picture
  - Output: Succinct representation of its object(s)
- **Theorem.** Can utilize model that solves the previous task as a primitive to solve this task.



Modular Networks 101

- Module: independent neural network component.
- Modules communicate via one's output serving as another's input.
- **Intuition.** Convolutional Neural Nets first find low-level objects (edge) and build up to high-level objects (cat).

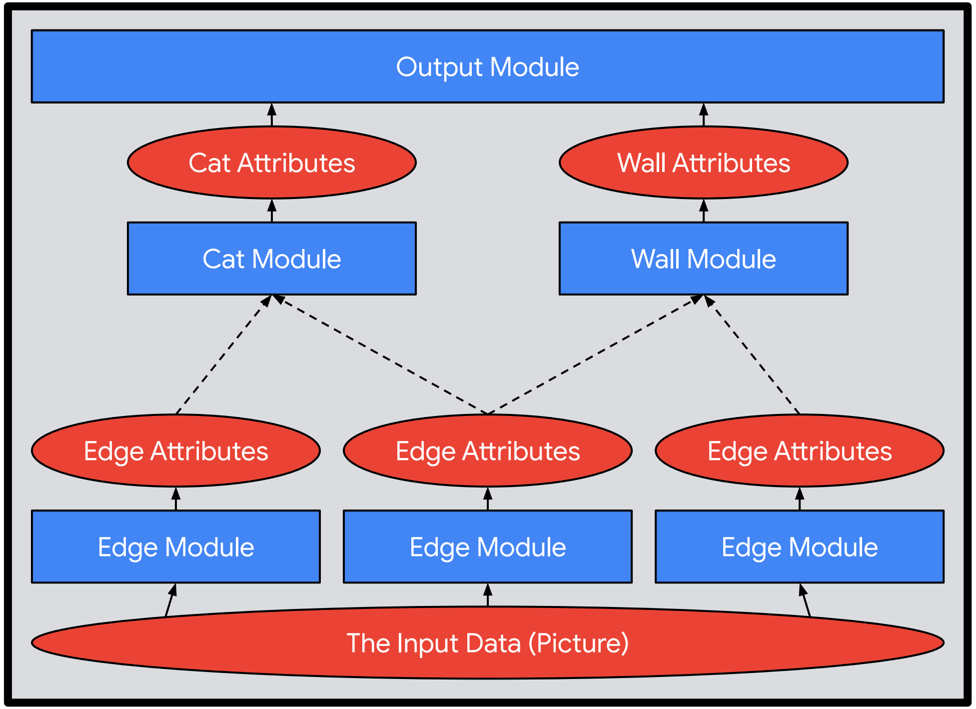
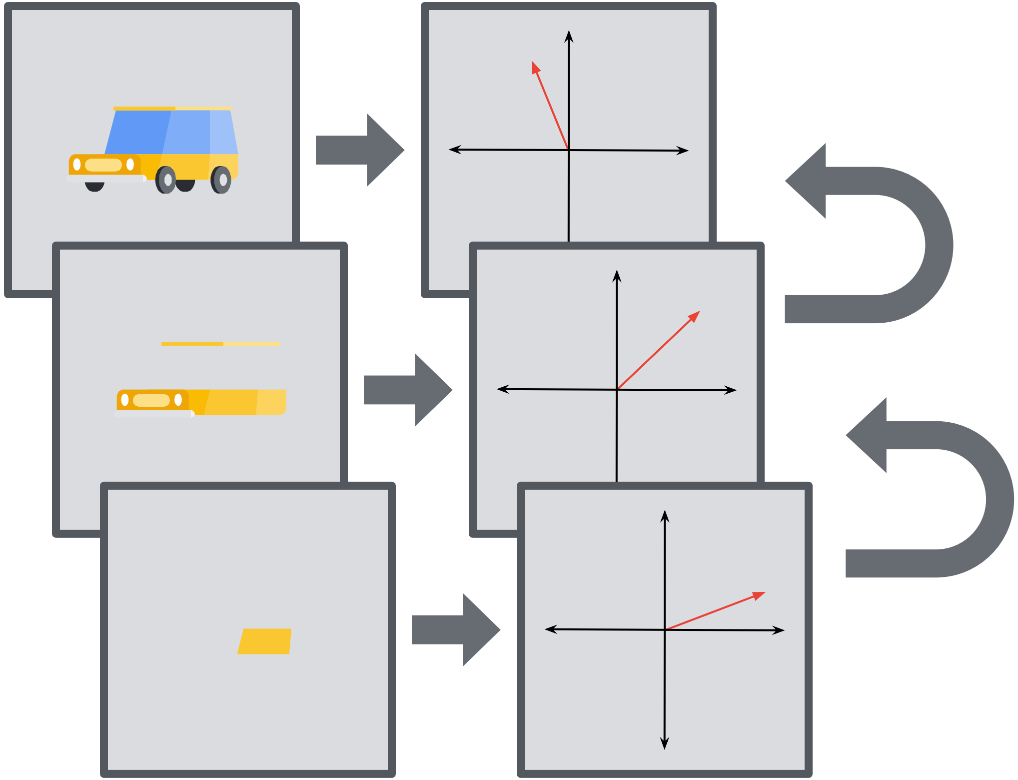


Figure. Abstract view of modular network processing image of a room.

Recursive Sketches

- Our mechanism creates a sketch for each object detected by the modular network.
- Recursive, because sketch of an object incorporates the sketch of sub-objects.
- Sketching tricks: (i) apply random matrix and (ii) take a weighted sum.
- Input represented by **top-level sketch**.



Provable Sketch Properties

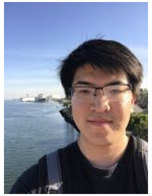
- **Attribute Recovery.** Object attributes can be approximately recovered from top-level sketch.
- **Sketch-to-Sketch Similarity.** Two completely unrelated sketches have small inner product; two sketches with similar objects have large inner product.
- **Summary Statistics.** If there are multiple objects produced by same module, can approximately recover their summary statistics like count/mean.
- **Graceful Erasure.** Erasing all but sketch prefix, we still get above properties (but increase recovery error).

Recursable Dictionary Learning

- Previous slide properties required knowing random matrices chosen by the sketch.
- **Recursable Dictionary Learning.** Given enough sketches, can approximately recover the random matrices (and object attribute vectors).
- Dictionary learning “unwinds” one level of sketching recursion.
- **Trickier than Classical Dictionary Learning.** The noisy output becomes noisy input for the next stage, so the error guarantee and error tolerance must be of the same form.

Recap: Recursive Sketches





- **Takeaway Message.** Can utilize model that solves the object recognition as a primitive to generate useful and efficient sketches of inputs.
- **Computing our Sketches.** Built out of (i) apply random matrix and (ii) take a weighted sum.
- **Let's chat!** Poster #73 @ Pacific Ballroom.