

WHAT ARE OUR CAMERAS SAYING?

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Alex Goldmark & Liza Stark

PEOPLE COMMUNICATE VISUALLY





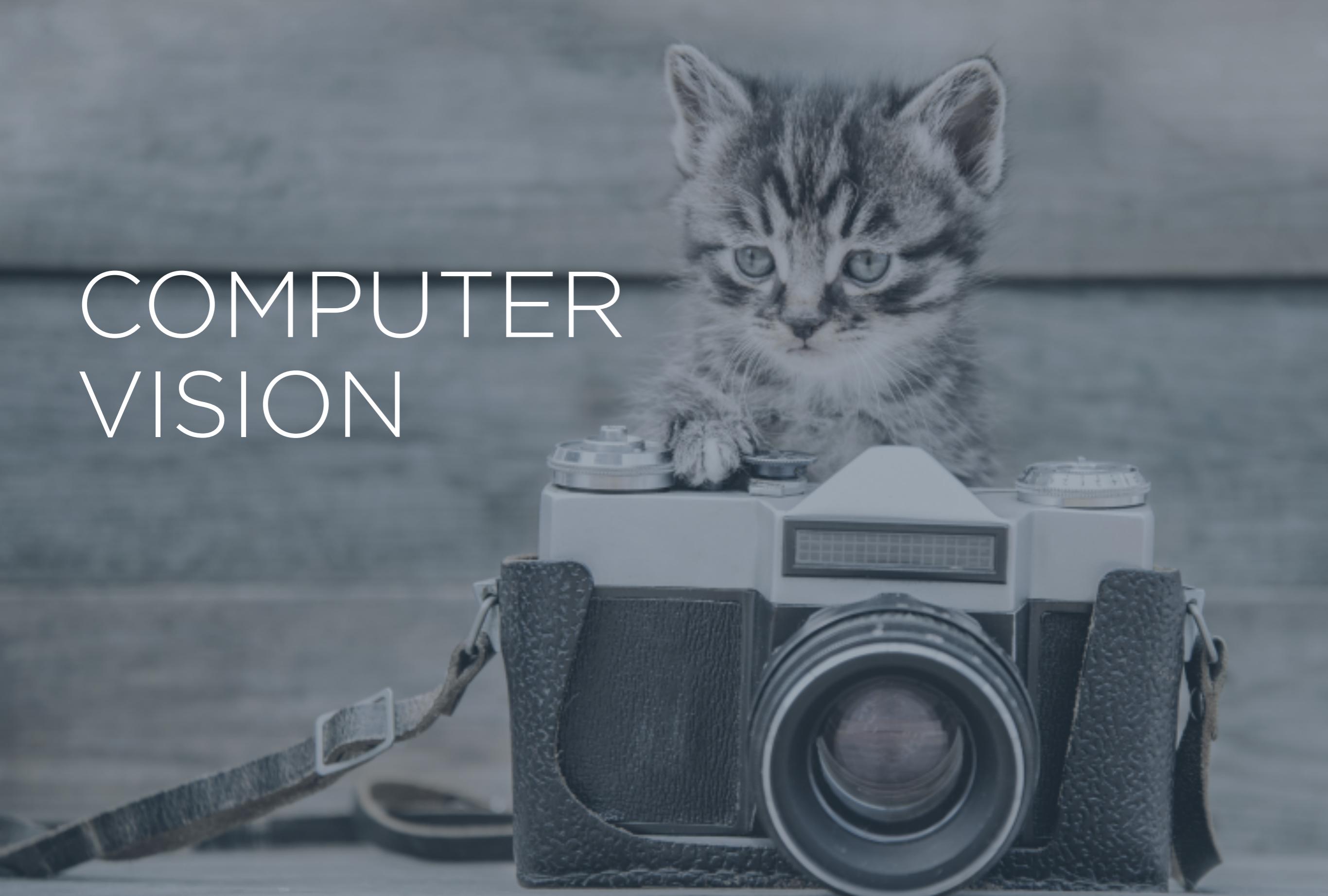




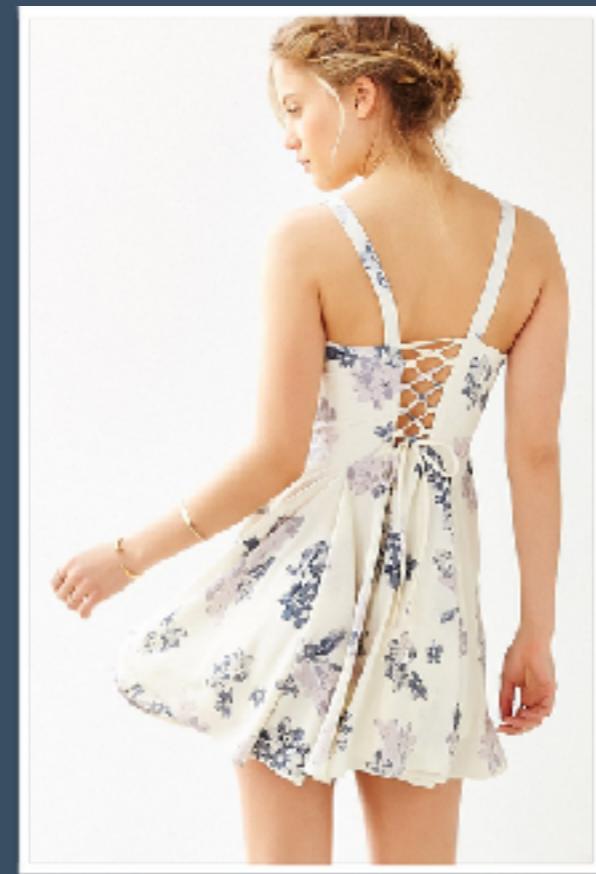
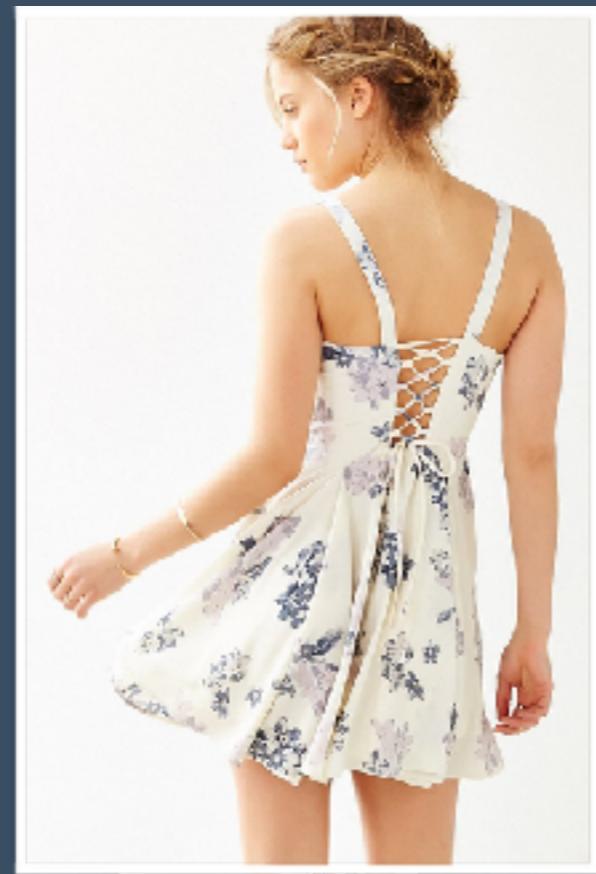
- PHL/NYC/SEA
- VC Funded
- *We're Hiring!*



COMPUTER VISION



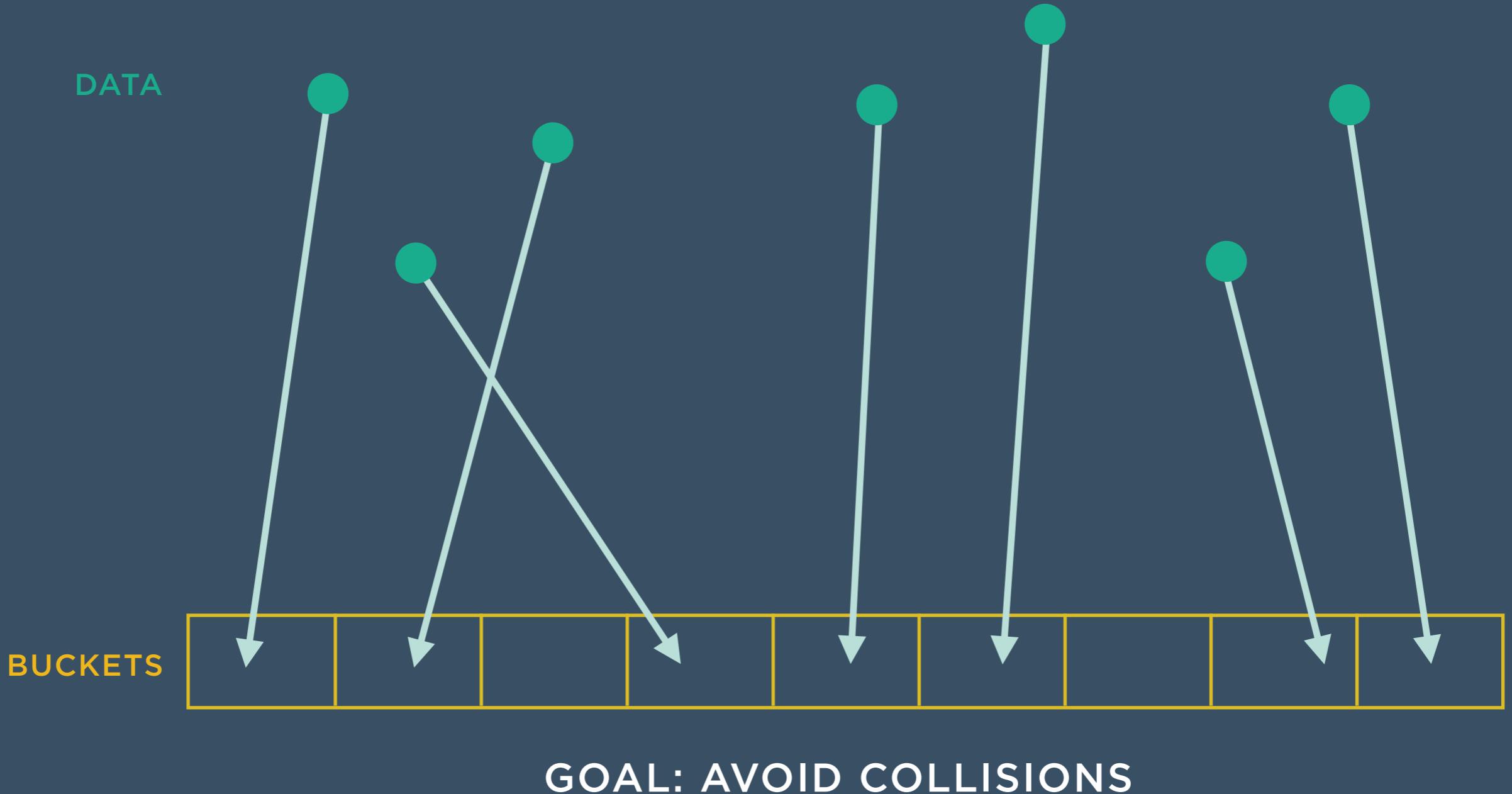
ARE THESE TWO PICTURES THE SAME?



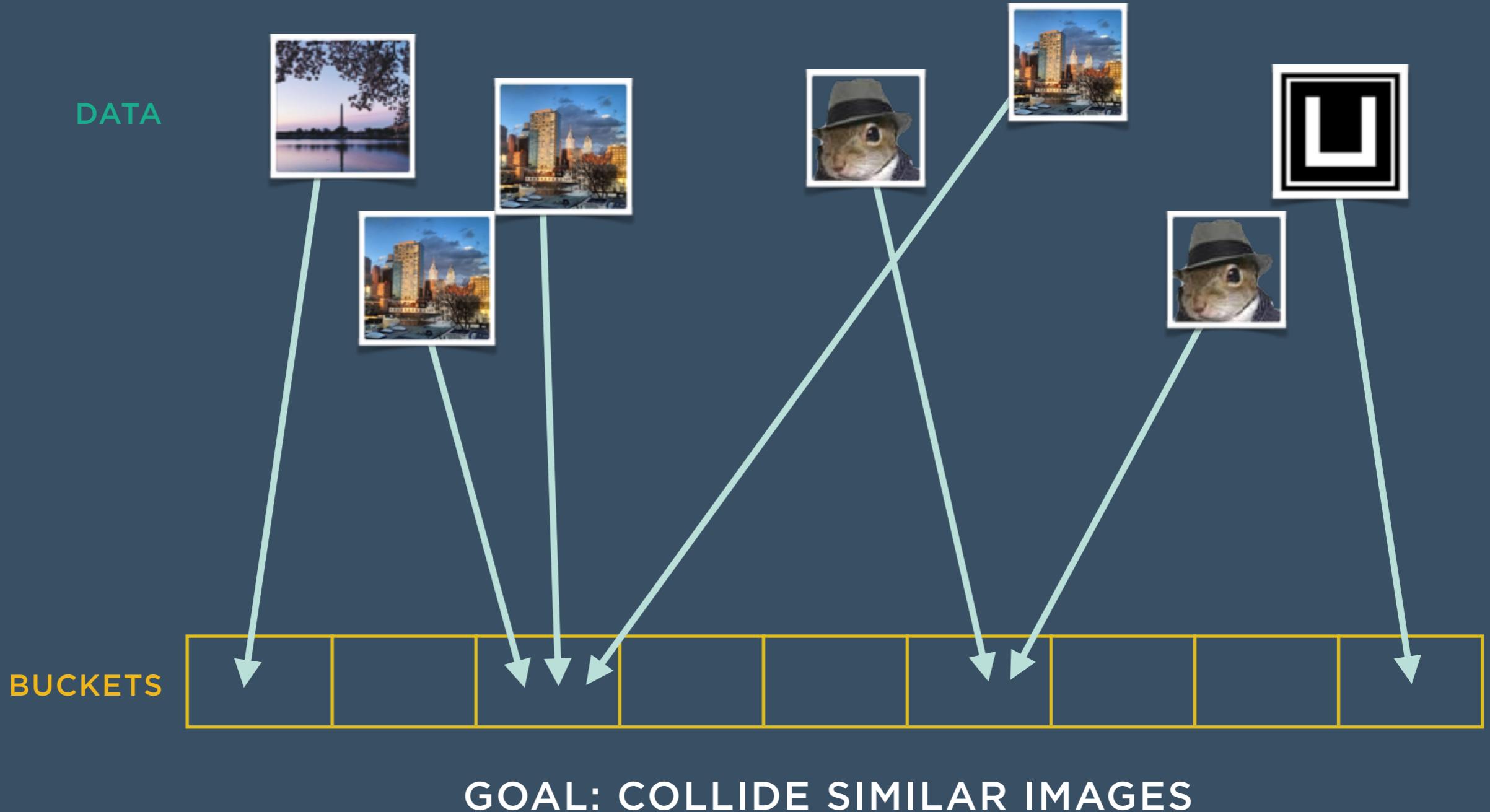
$$|a - b| \leq r$$

GOAL: MINIMIZE DATABASE QUERIES

HASHING

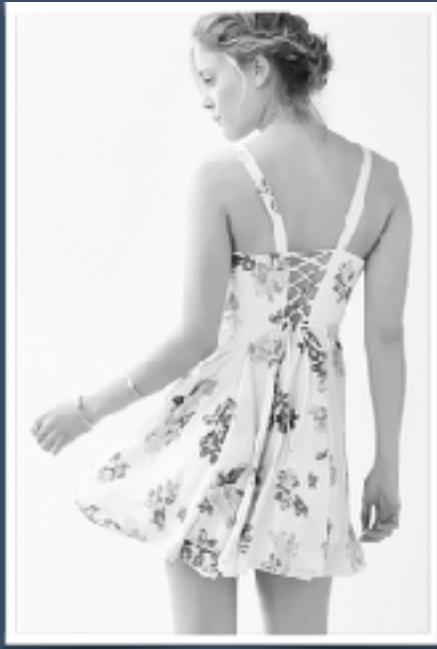


PERCEPTUAL HASHING

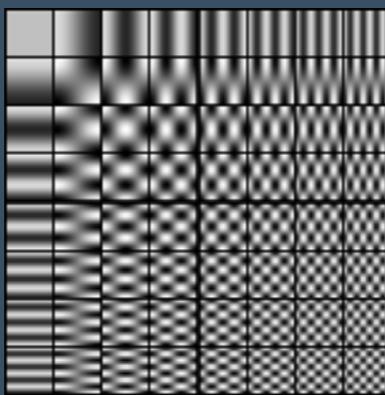


DISCRETE COSINE TRANSFORM

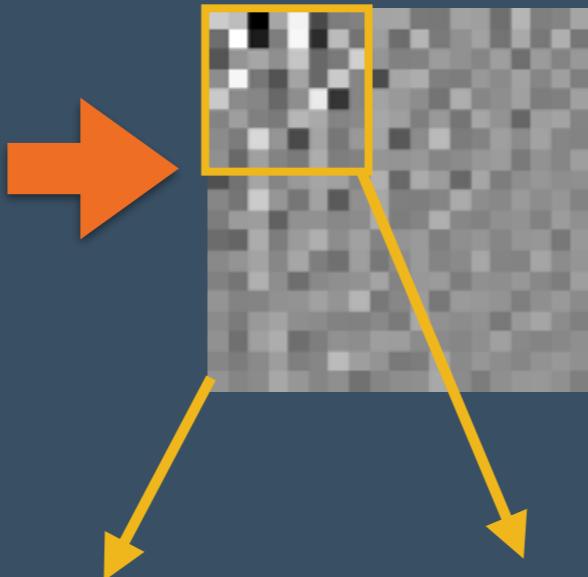
Input



Frequencies



DCT Coefficients



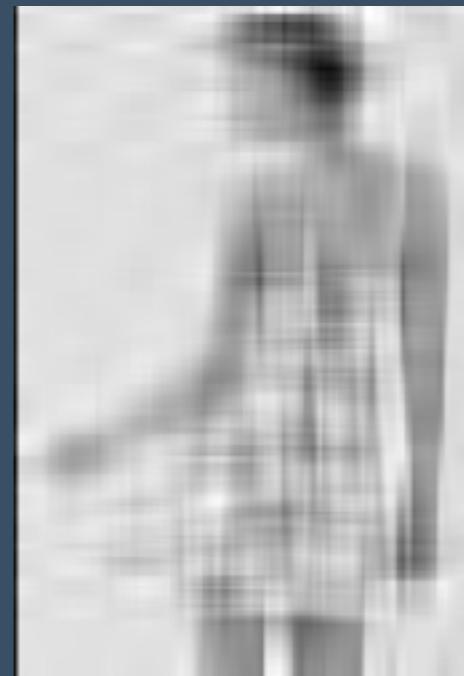
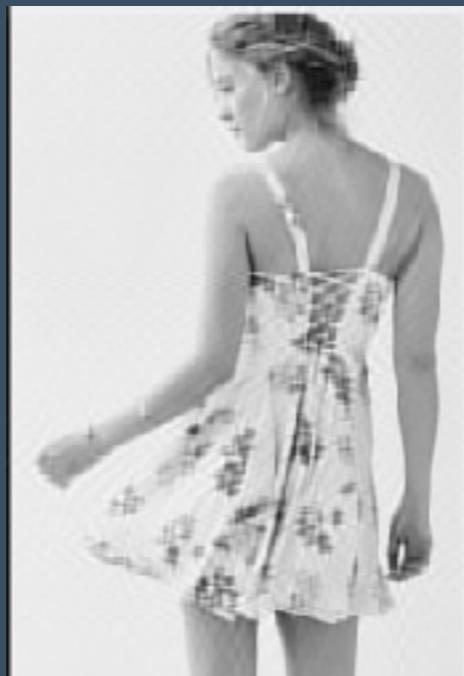
10,000 Coefficients



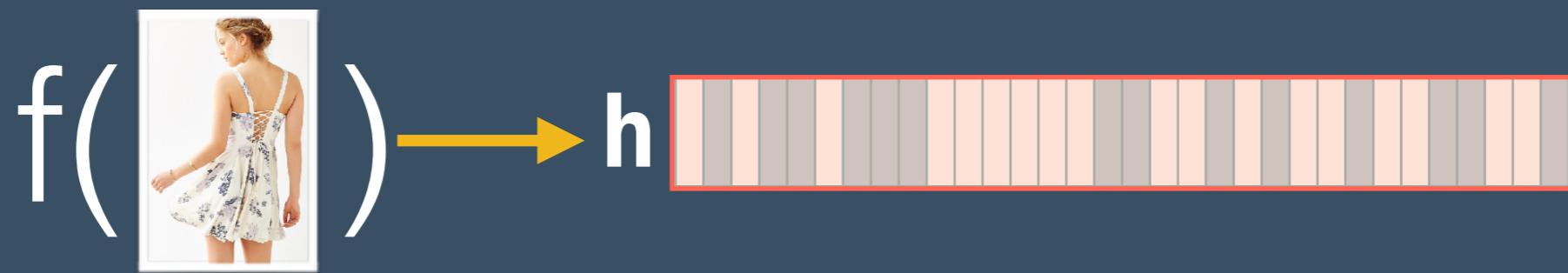
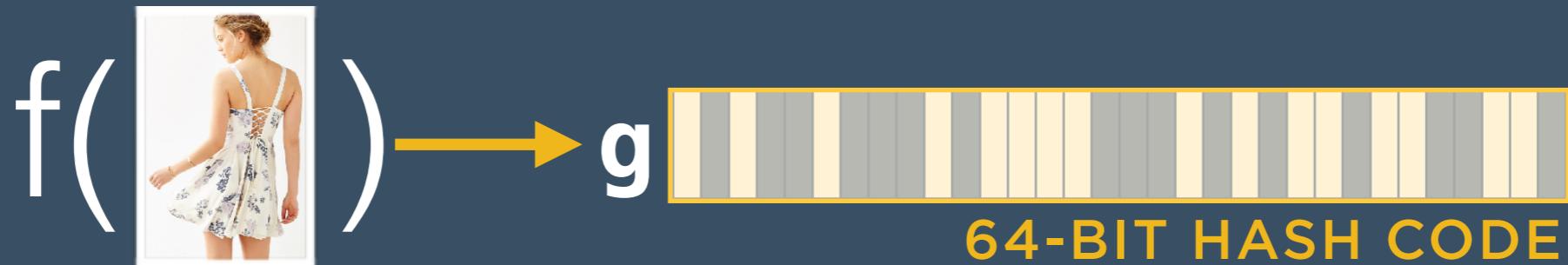
64-BIT HASH CODE



64 Coefficients

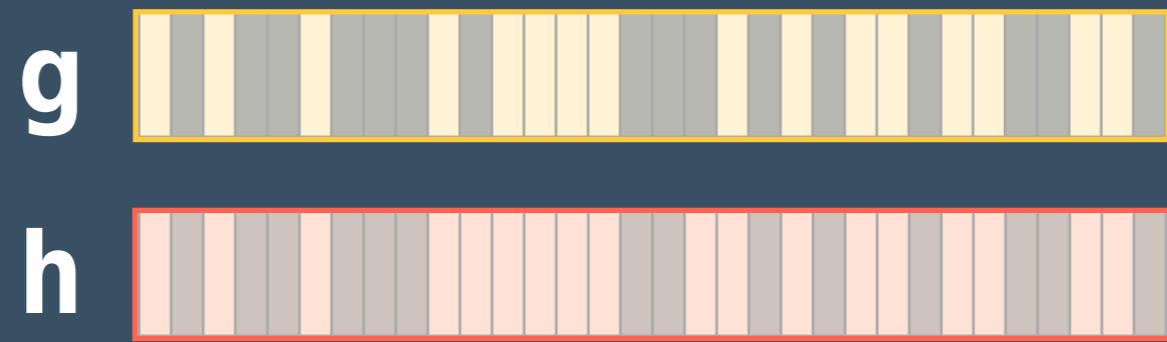


PERCEPTUAL HASHING



Same image iff: $\text{hamming-distance}(h, g) \leq r$

HASH QUERIES



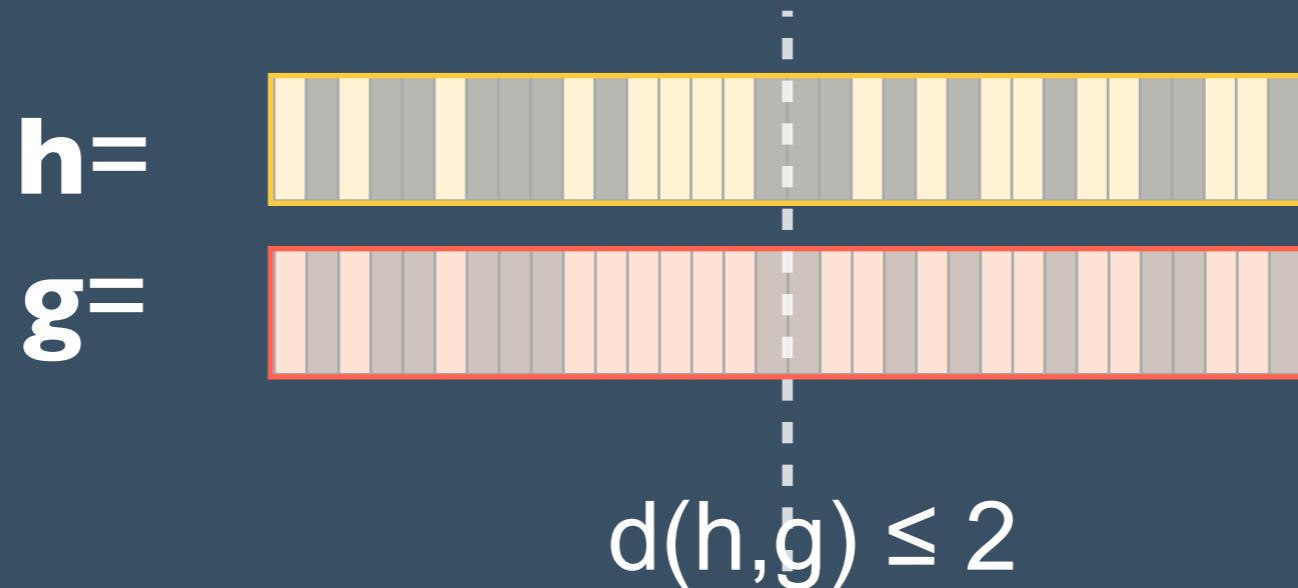
r	Queries
0	1
1	64
2	2016

$$\text{Total Number of Queries} = \sum_{k=0}^r \binom{b}{k} = 2081$$

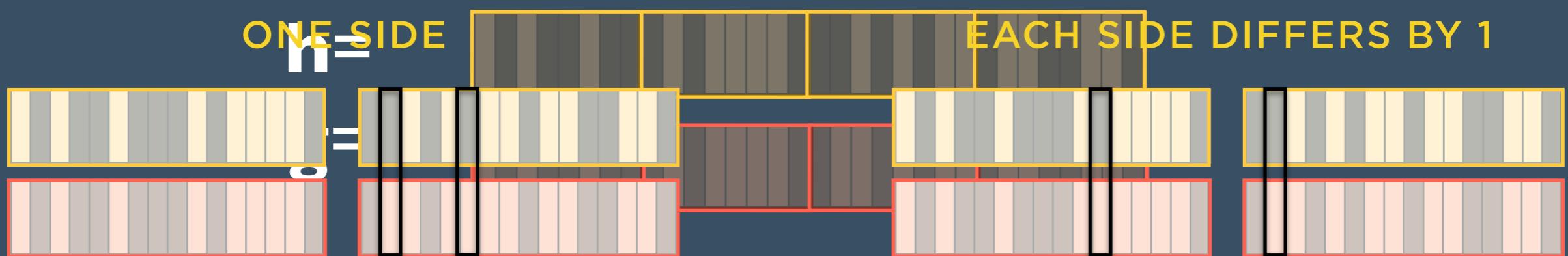
CAN
WE DO
BETTER?



MULTI-INDEX HASHING



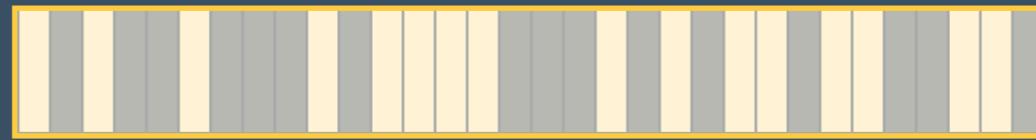
split into **m** sub-^{EITHER:}hashes of **s** bits each



$$\exists i : d(g^i, h^i) \leq \lfloor \frac{r}{m} \rfloor$$

MULTI-INDEX HASHING

Fingerprint



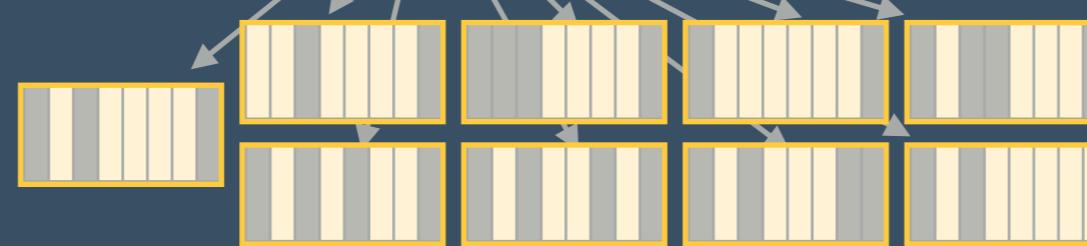
Split



m

sub-hashes

Permute



$$\sum_{k=0}^{\lfloor \frac{r}{m} \rfloor} \binom{s}{k}$$

permutations
per sub-hash

Query Multi
Index Table

```
SELECT hashes
WHERE sub-hash IN ...
AND hamming(...) ≤ r;
```

$$\frac{N}{2^s}$$

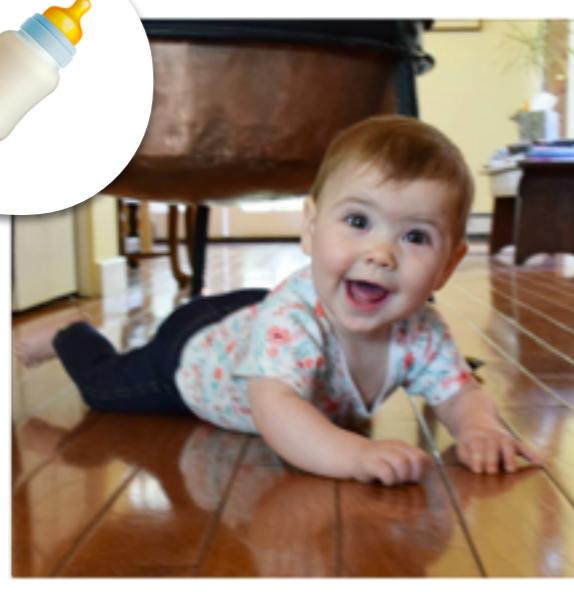
fingerprints
per sub-hash

ONLY 66 DATABASE QUERIES!

IMPLEMENTATION

- Architecture:
 - AWS Web Service
 - C++/Scala
 - NoSql Tables in Dynamodb
 - Scales *Linearly* with database queries!
- Stats:
 - Deployed since 2012
 - ~75 new images/second
 - 3.7 billion images

EMOJI: WHAT DO THEY MEAN?

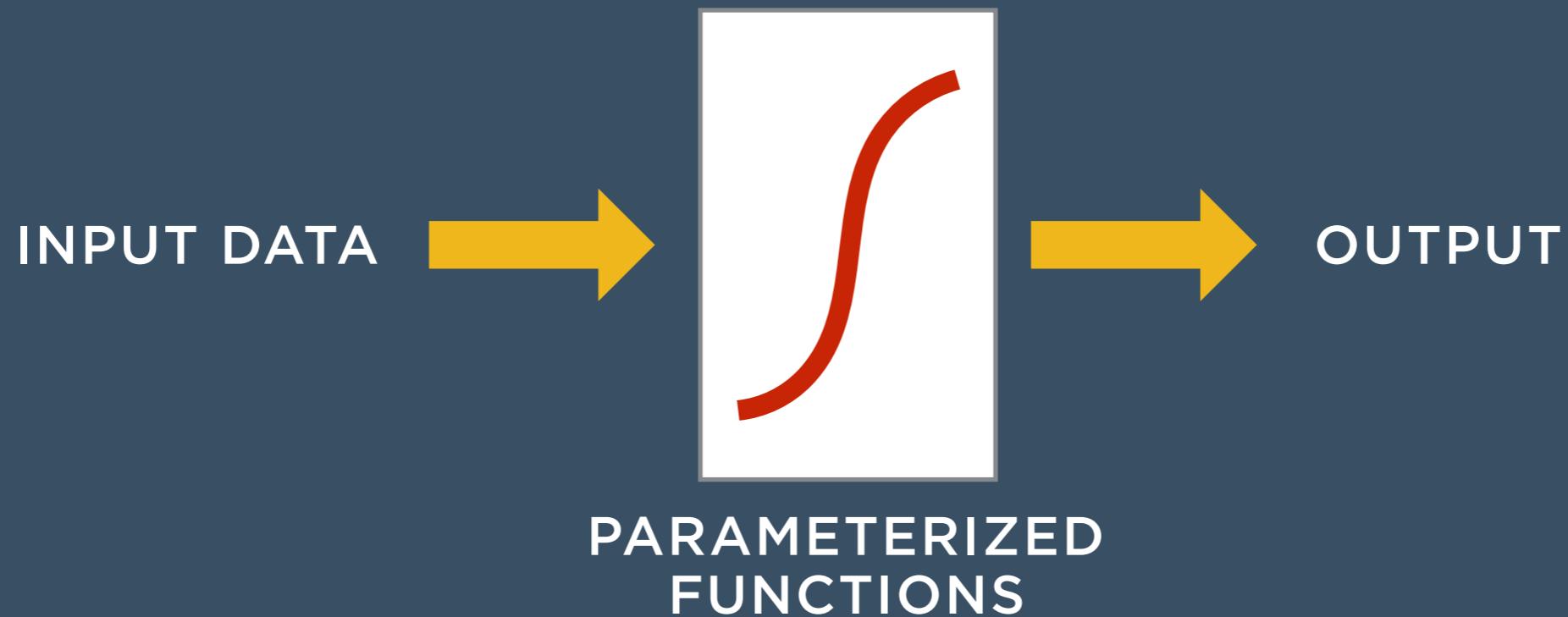


100



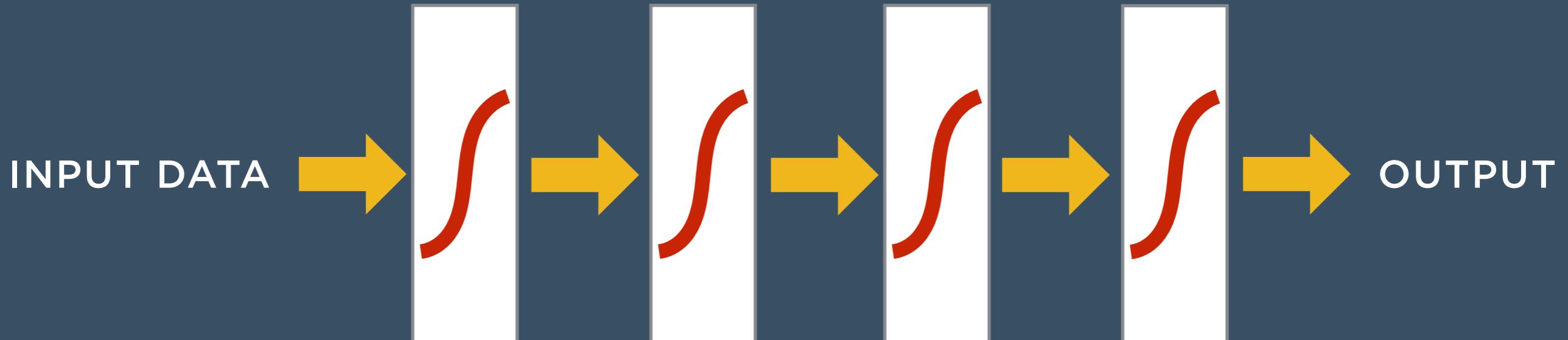
?

MACHINE LEARNING



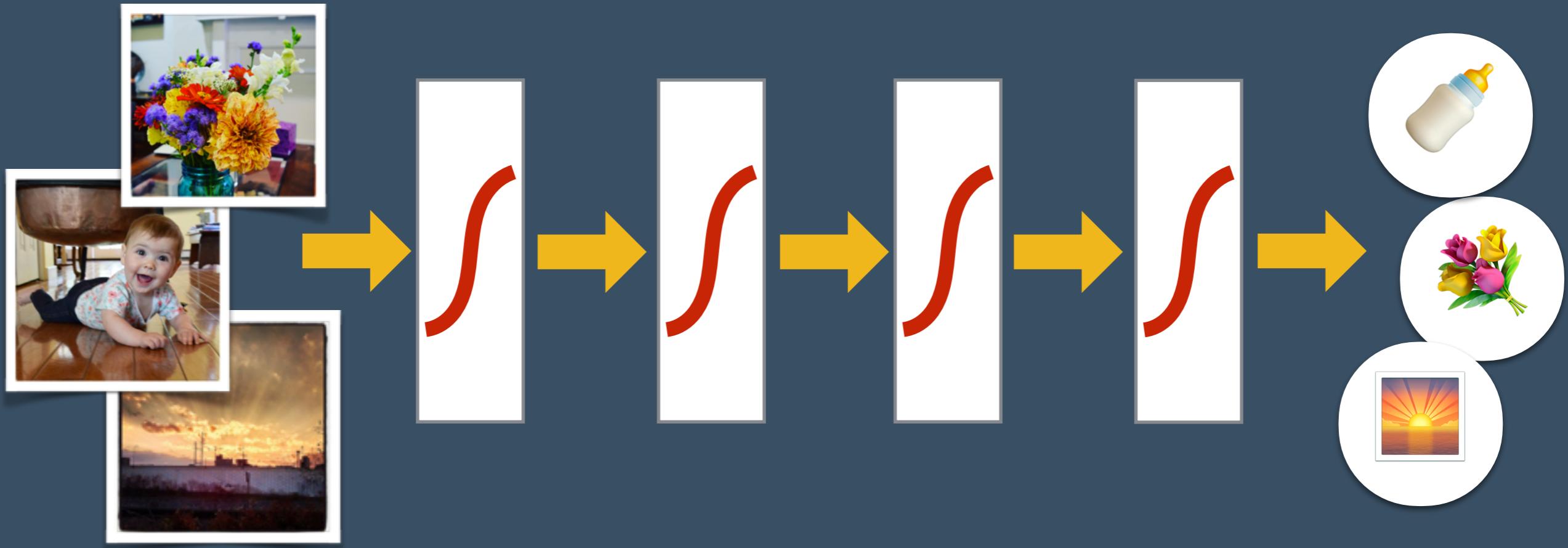
DEEP LEARNING

INTERMEDIATE REPRESENTATIONS



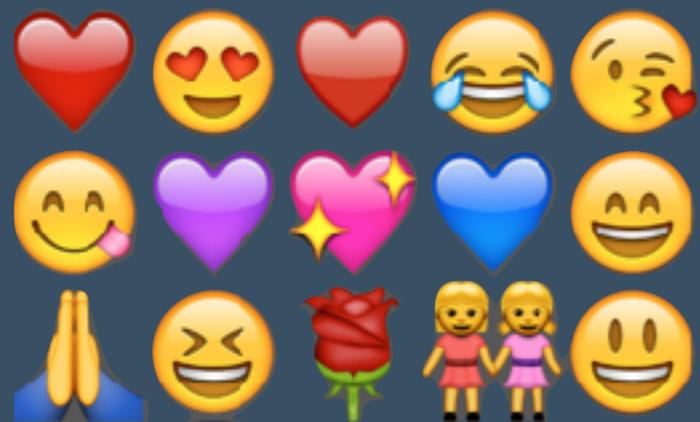
DEEP LEARNING

INTERMEDIATE REPRESENTATIONS

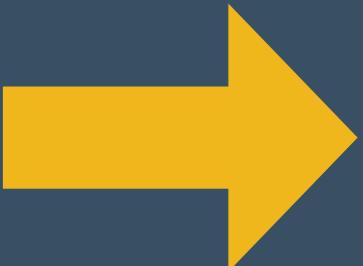
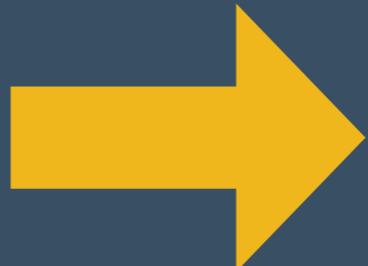


BREWING EMOJINET

Top 500 Emojis

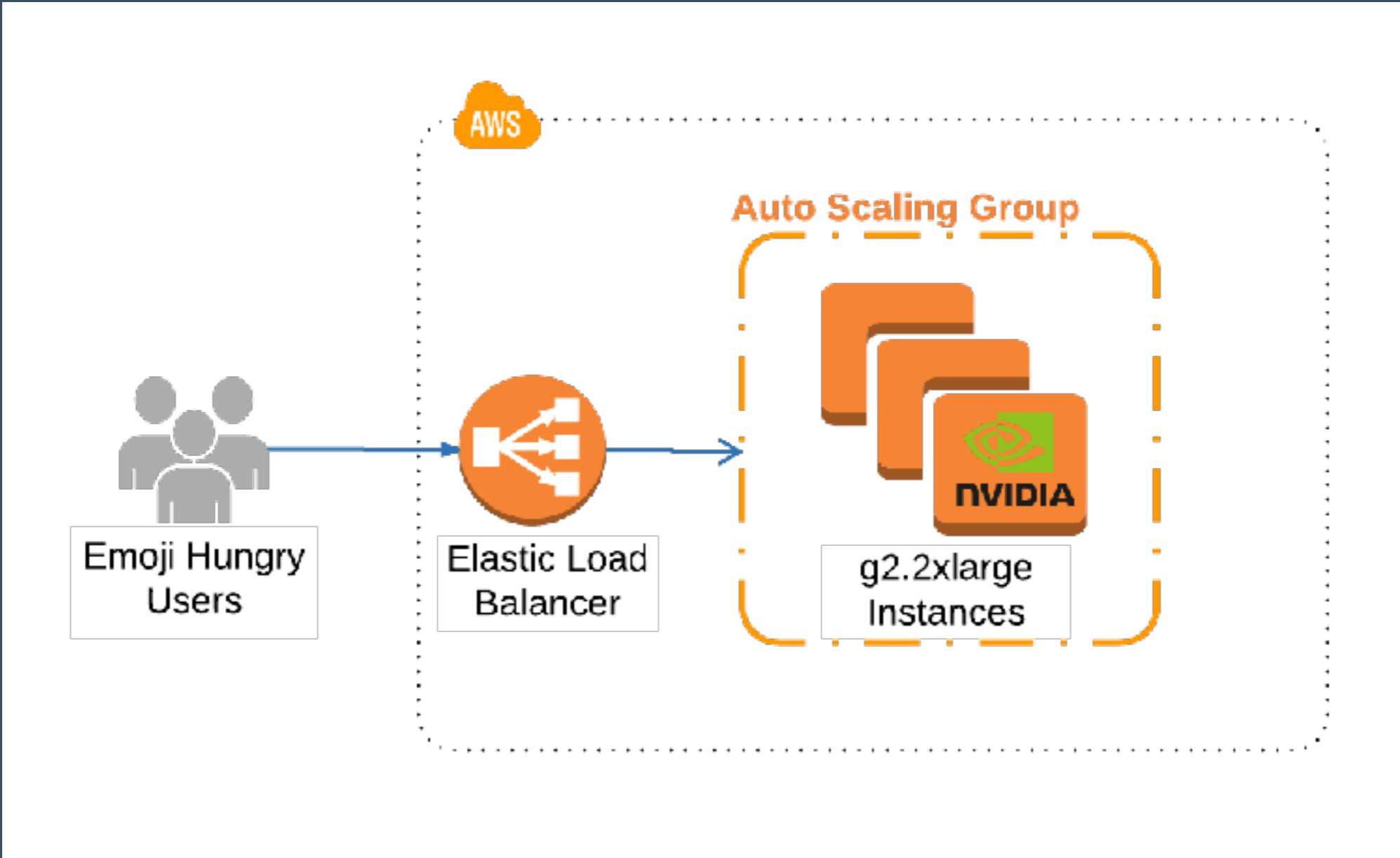


Instagram API



GET: /v1/tags/😊/media/recent

EMOJI WEB SERVICE



WHEN DO WE SCALE OUT?

EMOJI WEB SERVICE

- Lock GPU with actor singleton
- Akka ask pattern for async abstraction
- Publish wait time to Cloudwatch
- Scale ASG based on wait time

Actor

```
object EmojiNetActor {  
    val instance = actorSystem.actorOf(Props(new EmojiNetActor))  
}
```

```
private class EmojiNetActor() extends Actor {  
    def receive: Receive = {  
        case (image: BufferedImage, queueTime: Long) => {  
            val waitTime = now() - queueTime  
            cloudwatch.putMetricData(... waitTime ...)  
            val emojis = emojiDeepNet.hitGPU(image)  
            sender ! emojis  
        }  
    }  
}
```

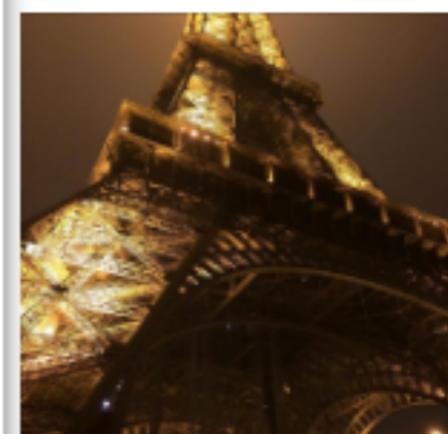
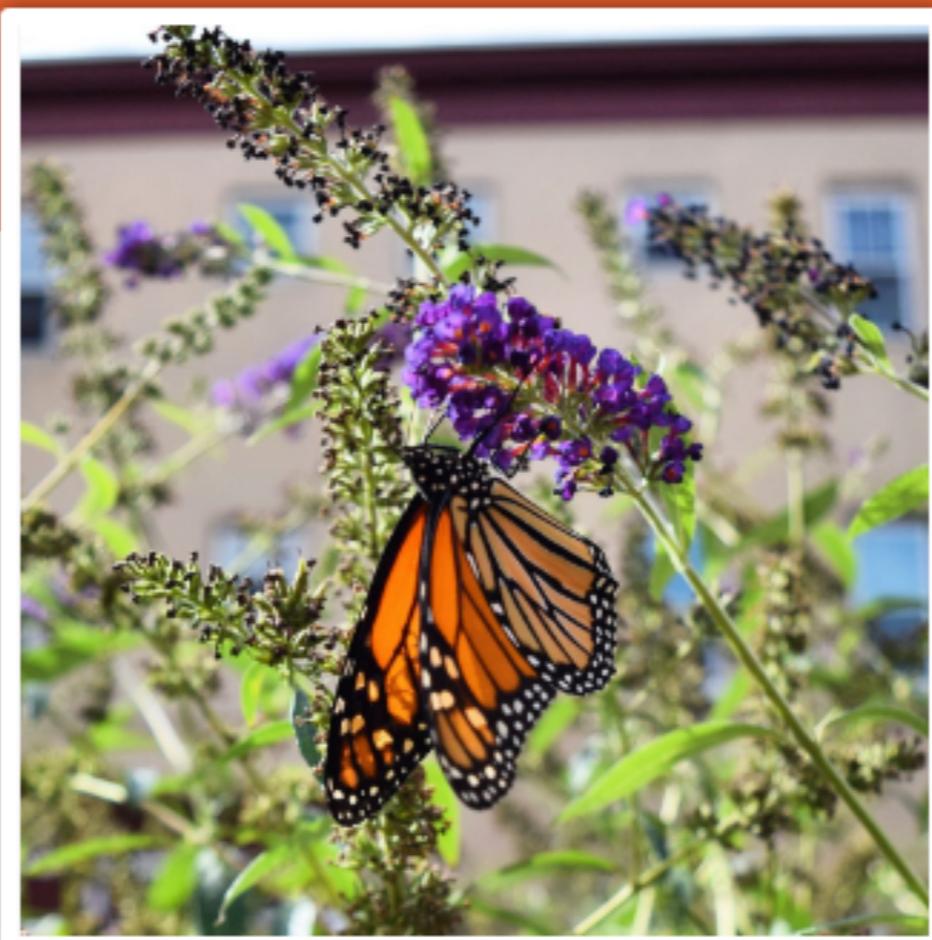
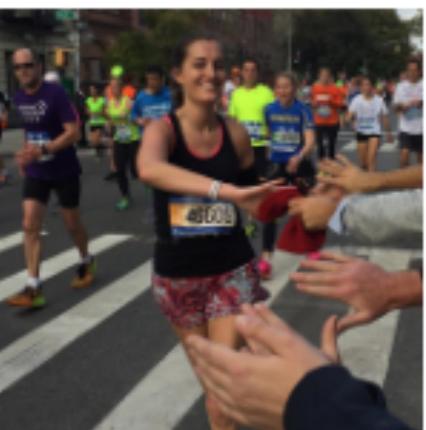
Consumer (Web Thread)

```
implicit val timeout = Duration(1, "second")  
def getEmojis(image: BufferedImage):  
    Future[EmojiResult] = {  
        val request = (image, now())  
        EmojiNetActor.instance.ask(request).map {  
            case x: EmojiResult => x  
            case _ => throw ....  
        }  
    }
```



THE EMOJINI 3000

The Internet's Premiere Emoji Granting Genie



GRANT EMOJIS

Try Your Own Photo:



CONNECT

OR

Enter Image URL

GO!

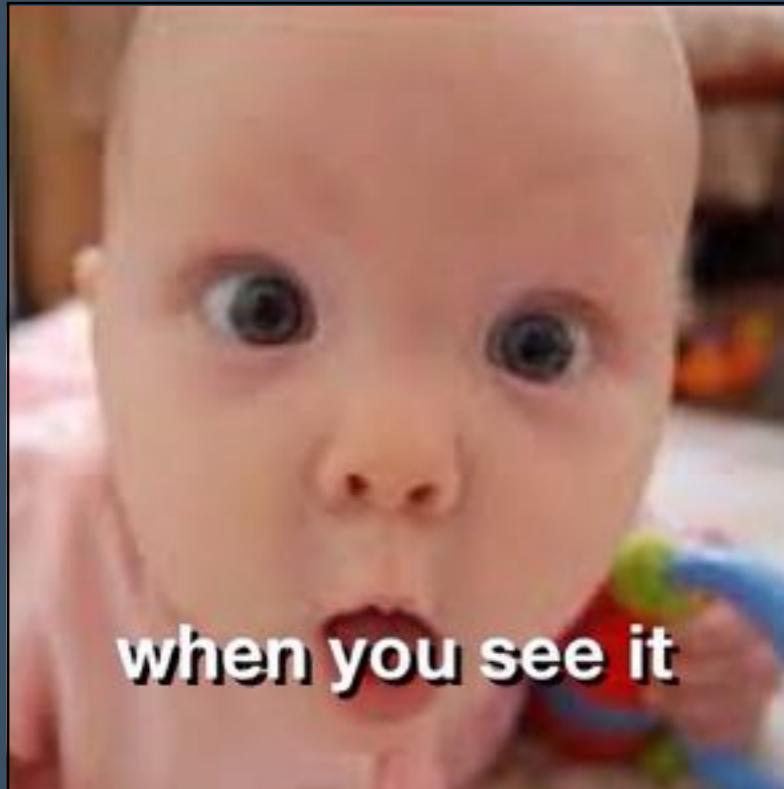
OR

UPLOAD

TOP RESULT FOR .



TOP RESULT FOR 😂



TOP RESULT FOR



TOP RESULT FOR

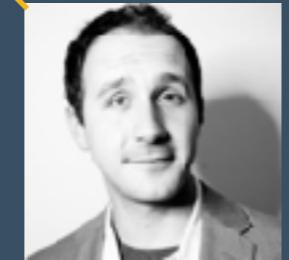


TOP RESULT FOR 🙌





*The winking bunny
goes a long way.*



Alex Goldmark



THANK YOU!

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