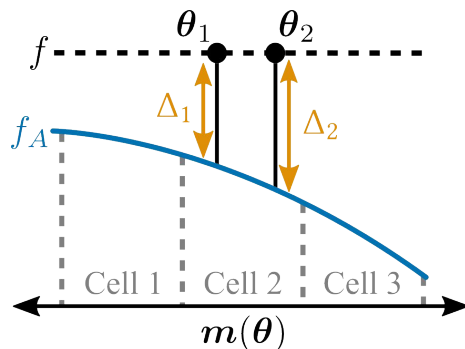


# Discount Model Search for Quality Diversity Optimization in High-Dimensional Measure Spaces

Bryon Tjanaka, Henry Chen, Matthew C. Fontaine, Stefanos Nikolaidis  
*ICAROS Lab, University of Southern California*



[discount-models.github.io](https://discount-models.github.io)

## **Quality Diversity (QD) Optimization**

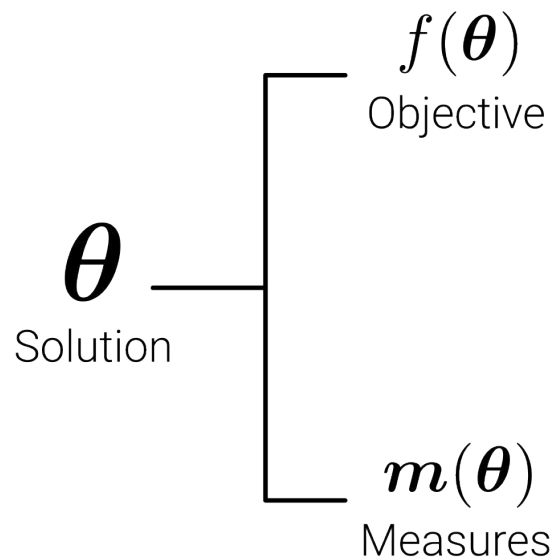
Find a collection of diverse, high-performing solutions.

# Quality Diversity: Problem Setup

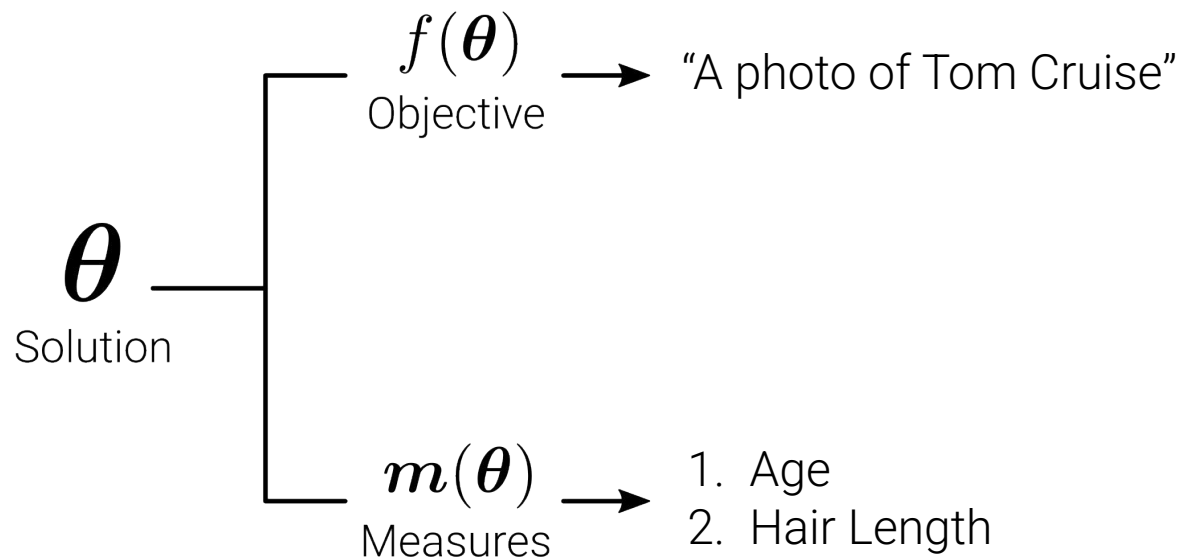
$\theta$

Solution

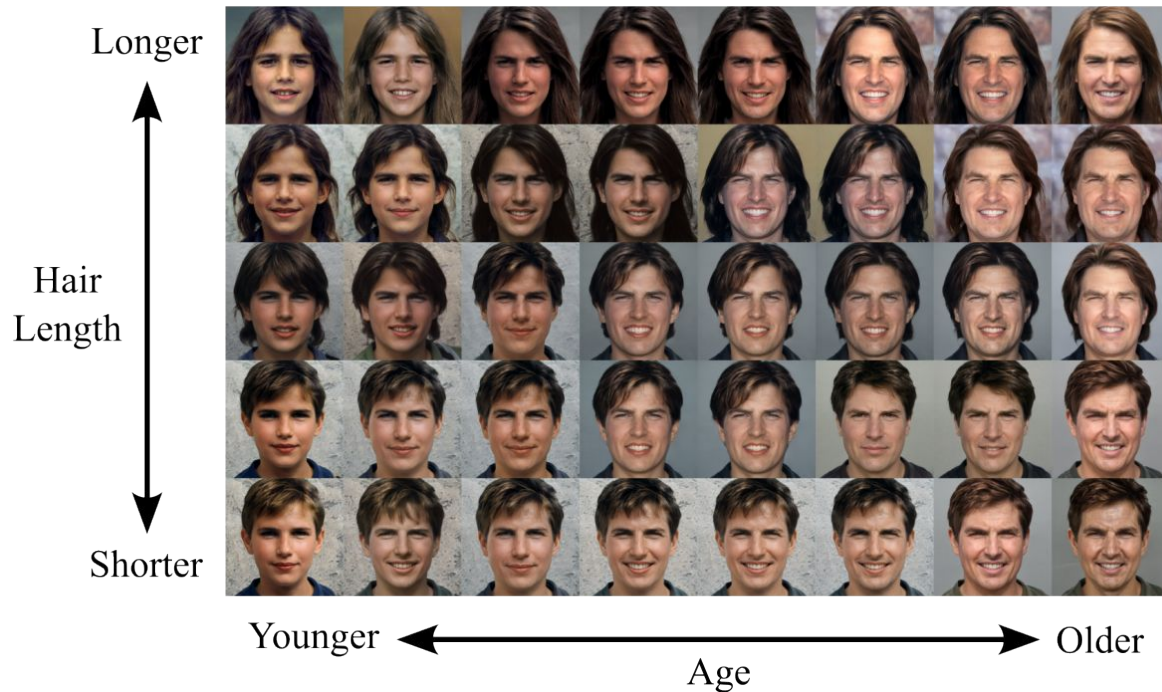
# Quality Diversity: Problem Setup



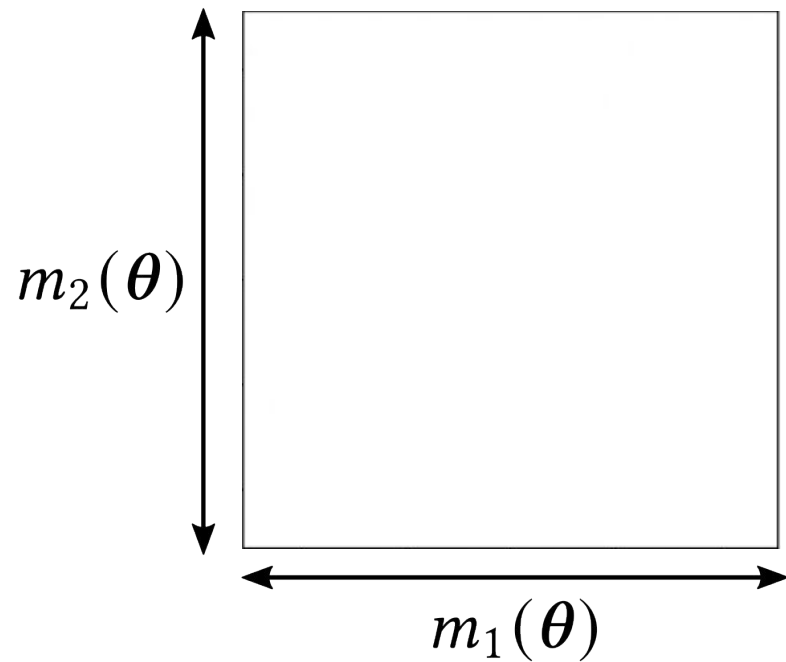
# Quality Diversity: Problem Setup



# Quality Diversity: Archive

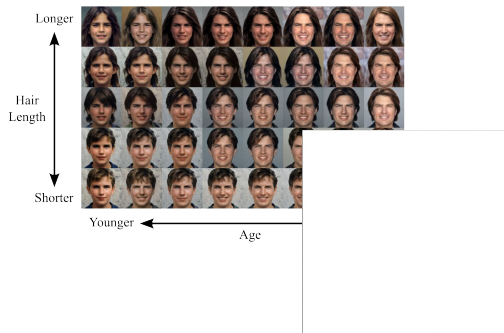


# Quality Diversity: Archive



# Goal: Improve measure space exploration, *especially in high-dimensional measure spaces.*

## Current QD Problems (2 measures)



## More Flexibility (3-10 measures)

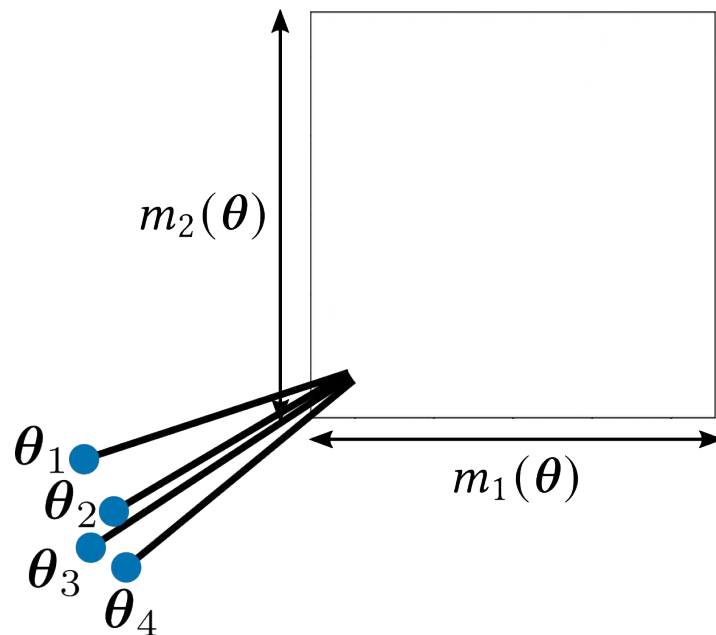
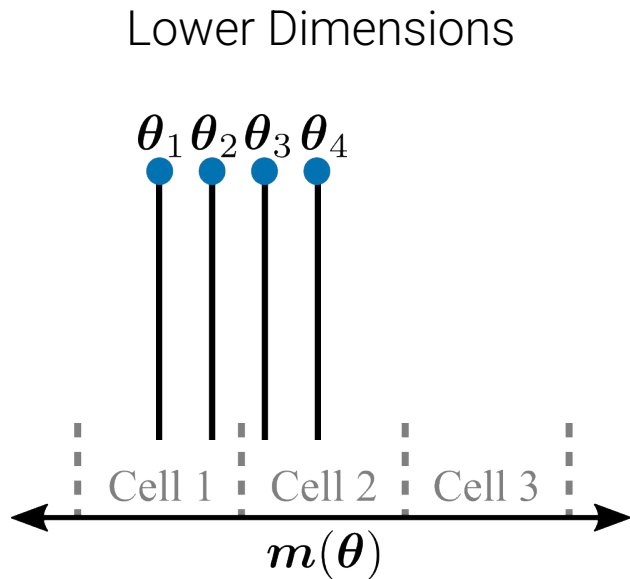
- Age
- Hair length
- Hair color
- Facial expression
- ...

## “Images as Measures” (>100k measures)



# Problem: Distortion

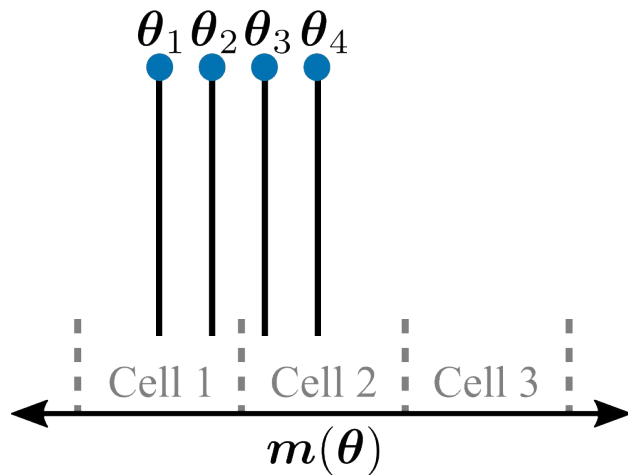
Multiple solutions have similar measures.



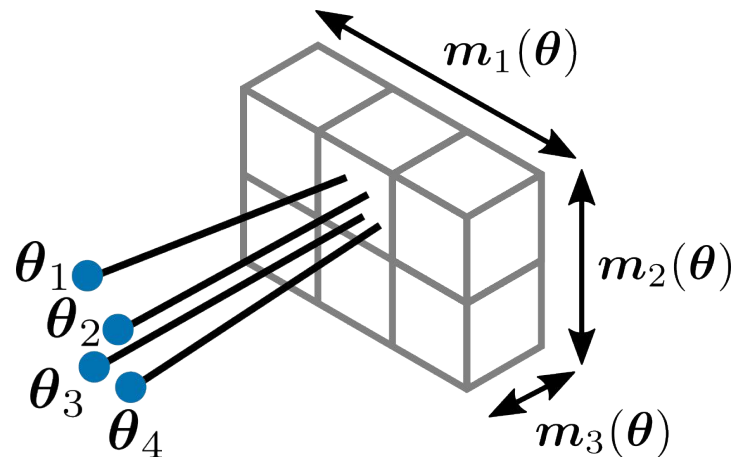
# Problem: Distortion

Multiple solutions have similar measures.

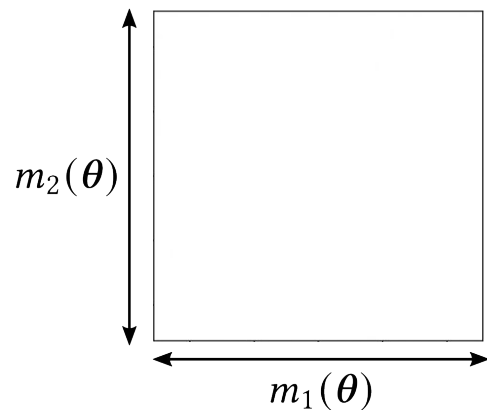
Lower Dimensions



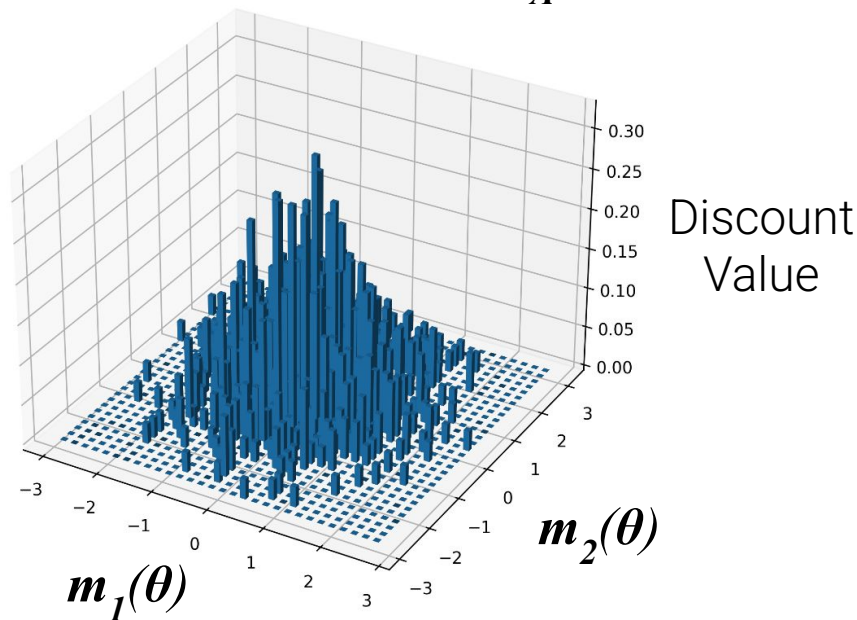
Higher Dimensions



# Distortion and CMA-MAE

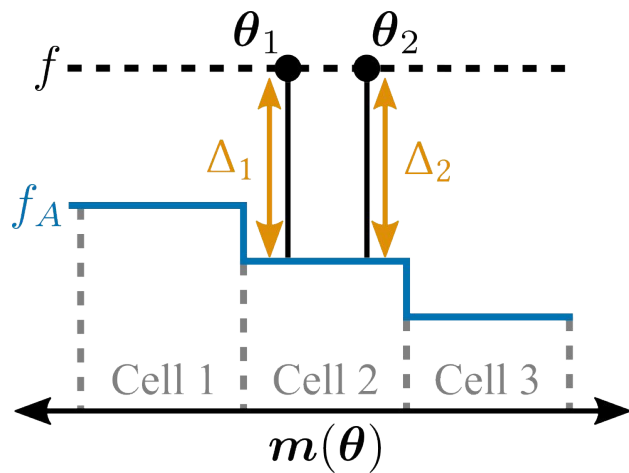


Discount Function  $f_A$



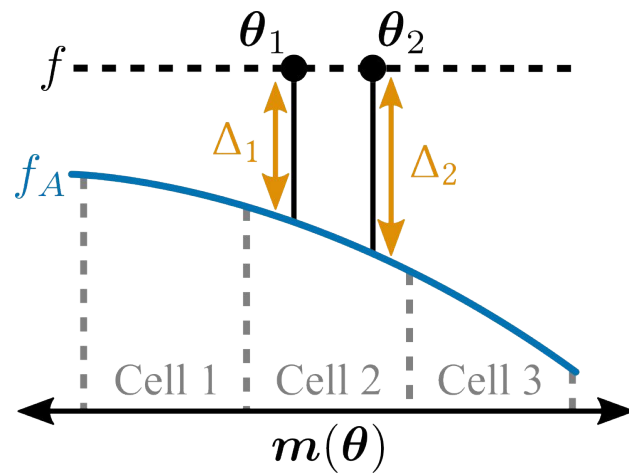
## CMA-MAE

Histogram Discount



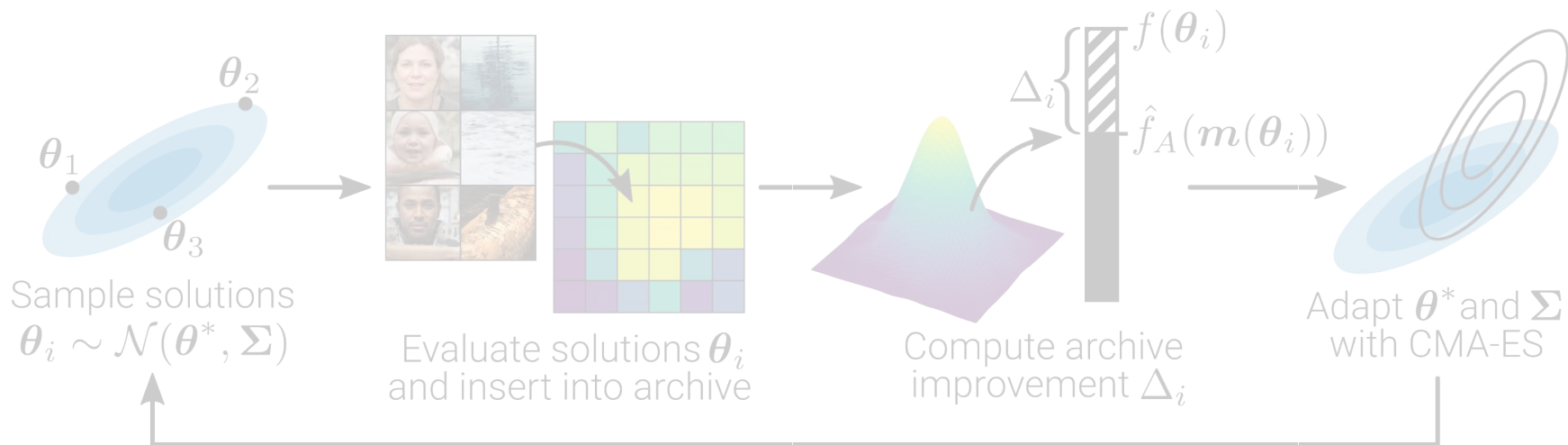
## Our Proposal

Smooth Discount



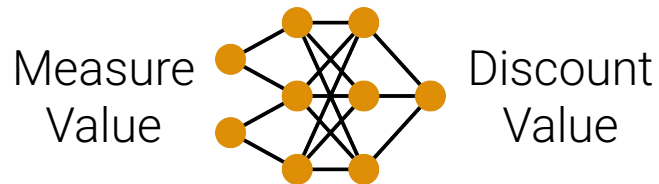
# Discount Model Search

Key Insight: Enhance measure space exploration with a smooth discount model.



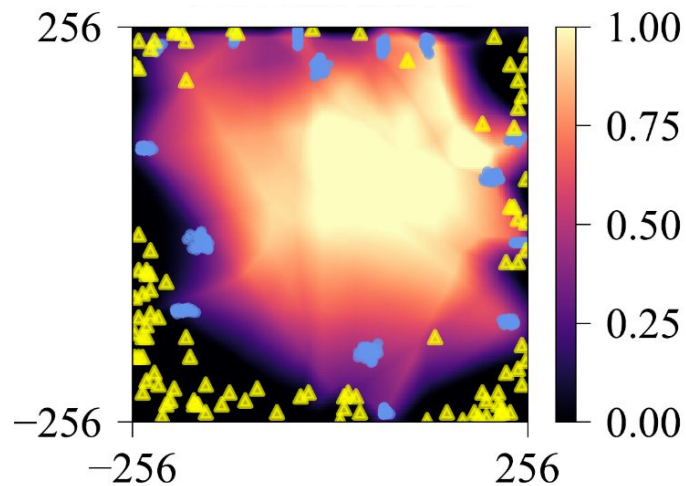
# Model Training

## Discount Model



## Dataset

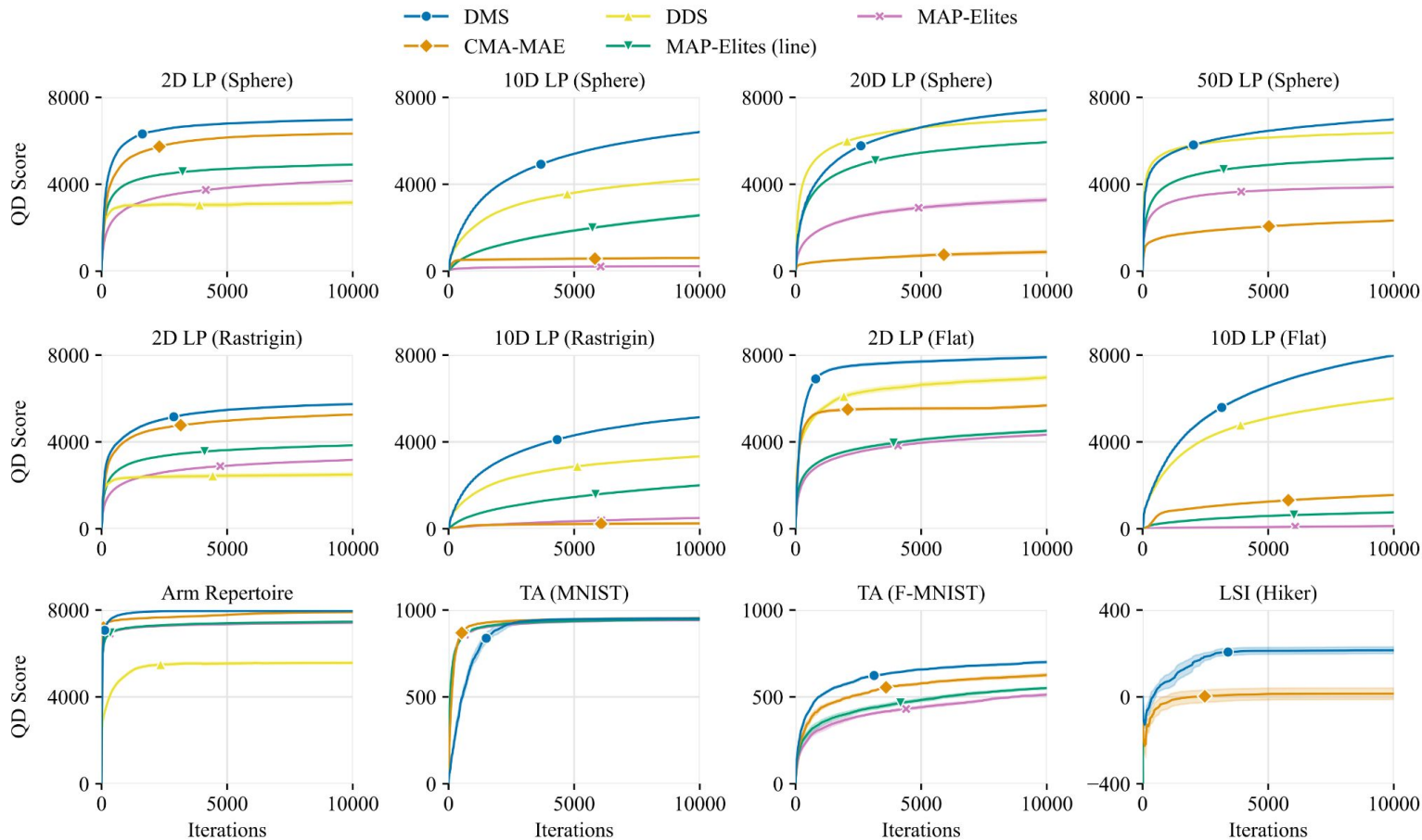
$(m_i, d_i)$



• Sampled Solutions

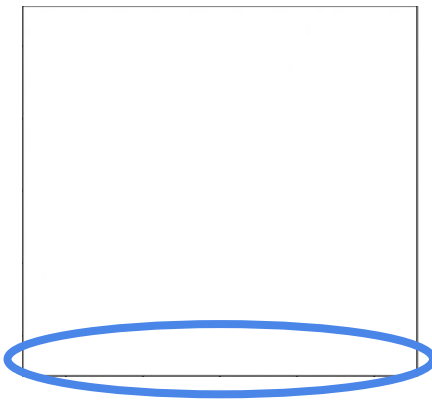
▲ Empty Points

# Experimental Results: QD Score



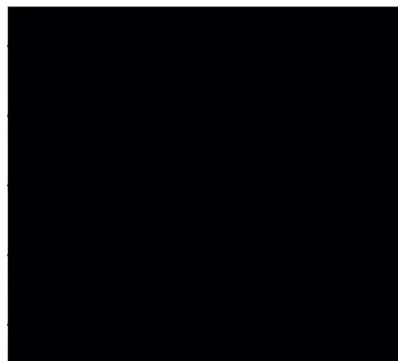
# Experimental Results: Heatmaps

CMA-MAE



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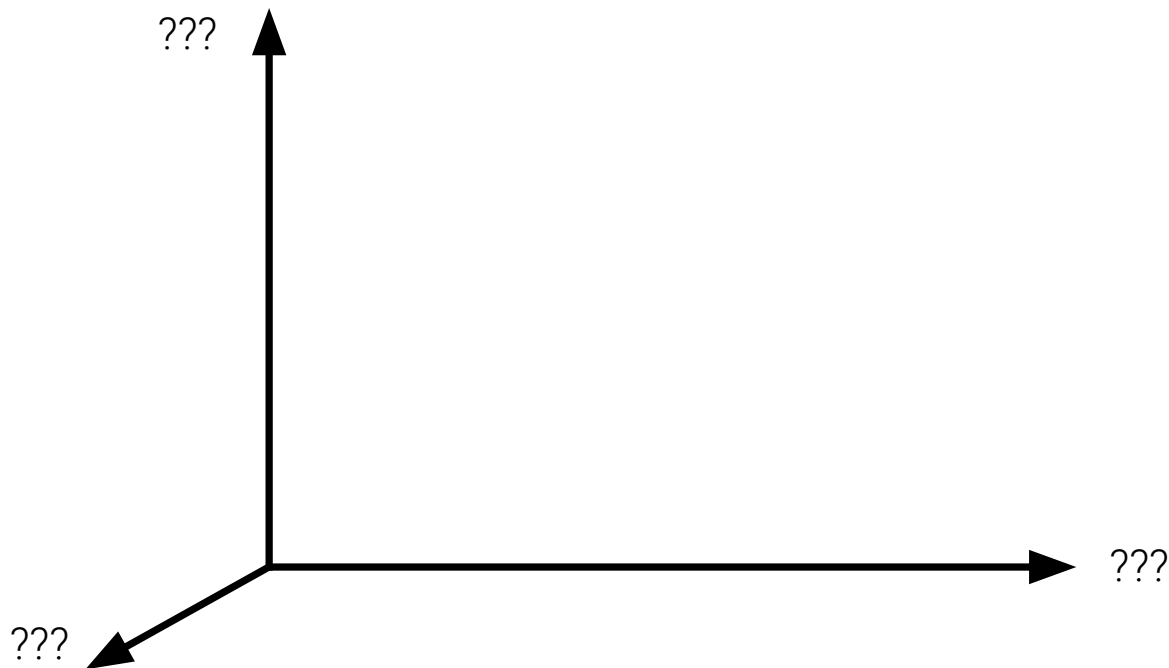
Discount Model Search



# Quality Diversity with Datasets of Measures (QDDM)

**Objective:** “A photo of the face of a hiker.”

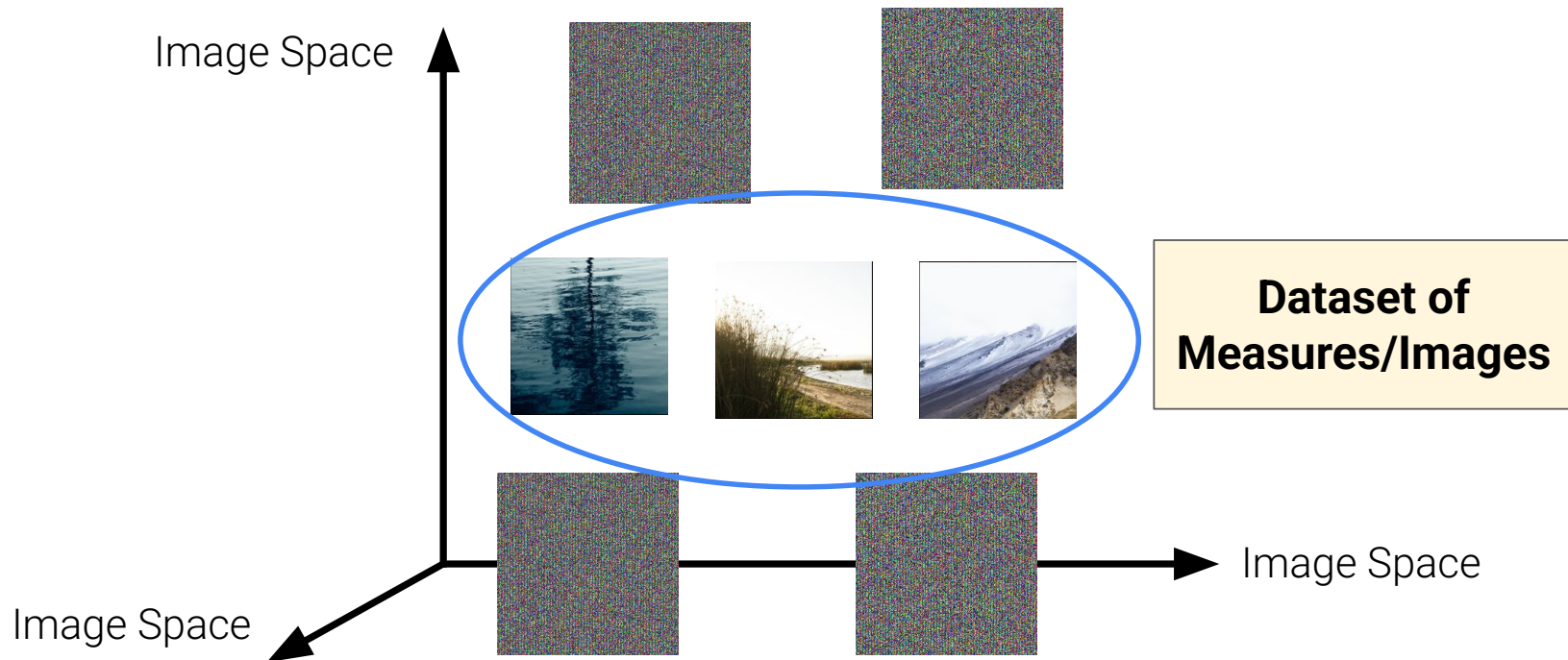
**Measures:** Where is the hiker located?



# Quality Diversity with Datasets of Measures (QDDM)

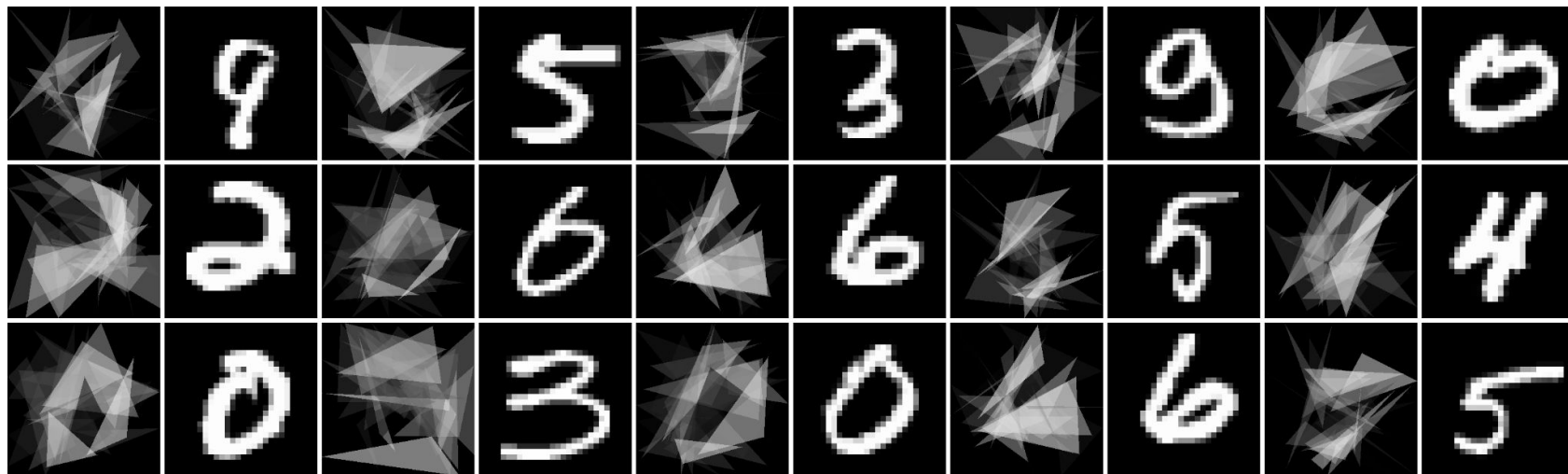
**Objective:** “A photo of the face of a hiker.”

**Measures:** Where is the hiker located? → **256x256x3 RGB images**





# QDDM: Triangle Arrangement



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