



## CHAMELEON

Foundation Models for Fairness-aware Multi-modal  
Data Augmentation to Enhance Coverage of Minorities

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# Motivation

Potential harms from the under-representation of minorities in data, particularly in multi-modal settings, is a well-recognized concern.

23 August 2023

## Driverless cars worse at detecting children and darker-skinned pedestrians say scientists

Researchers call for tighter regulations following major age and race bias in autonomous systems.

February 16, 2022

## Google's 'CEO' image search gender bias hasn't really been fixed

JULY 5, 2020 | 4 MIN READ

## Speech Recognition Tech Is Yet Another Example of Bias

## Study finds gender and skin-type bias in commercial artificial-intelligence systems

Examination of facial-analysis software shows error rate of 0.8 percent for light-skinned men, 34.7 percent for dark-skinned women.

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ated groups

# Motivation: HP Webcams



# How to resolve it?

Available sources for collecting more data?

- ① Yes: Distribution tailoring (Fair Data Integration) [NAJ21]
- ② No:?

Our Idea

Use generative AI to create synthetic data to resolve under-representation of minorities

Challenges

- ① Minimal set of synthetic tuples
- ② Semantic integrity of the dataset
- ③ Quality of generated tuples
- ④ Cost-effectiveness of repair process

# Problem Setting

## Given: Data Model

- A dataset of **multi-modal** tuples (e.g., images)  $\mathcal{D} = \{t_1, \dots, t_n\}$
- $d \geq 1$  attributes of interest  $\mathbf{x} = \{x_1, \dots, x_d\}$  (e.g., **gender**, **race**, **age-group**, etc.)
- Cartesian product of a subset of  $\mathbf{x}' \subseteq \mathbf{x}$ , form the **subgroups** (e.g., black-female)
  - ▶ **Level** of a subgroup: No. attributes in it (e.g.,  $\ell(\text{black-female}) = 2$ )
  - ▶ A **Combination**: A group  $g$ , where  $\ell(g) = d$

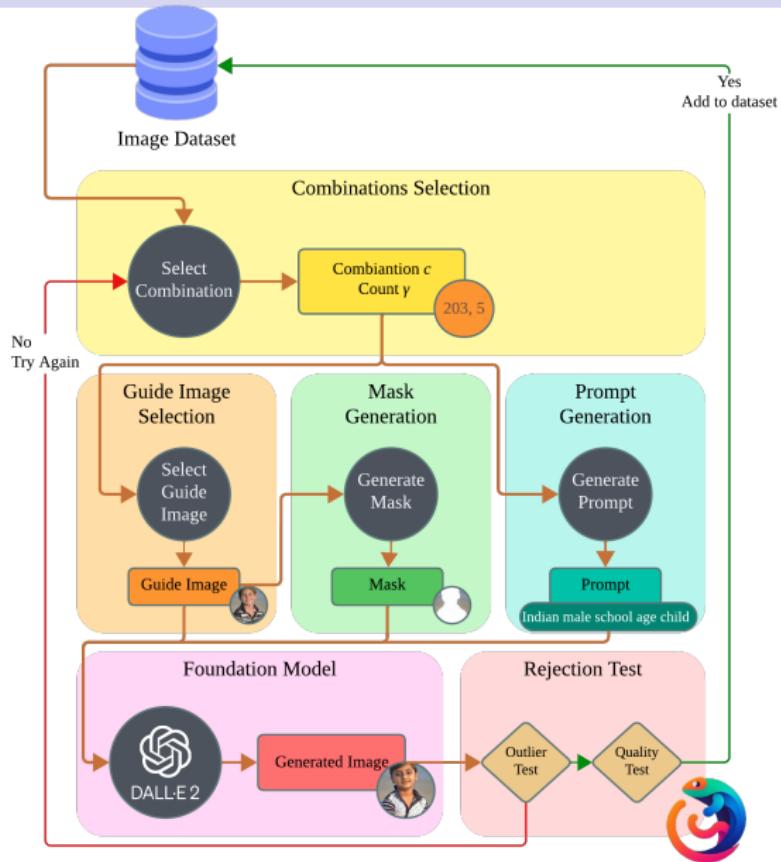
## Given: Foundation Model

Generates a synthetic tuple (e.g., image) based on a **Prompt**, and a **Guide**: a (tuple,mask) pair

## Goal

Minimally Augment the dataset to ensure coverage for all subgroups at a level  $\ell$

# System Overview



# Experiments Highlight: Image, Data Coverage

## FERET-DB

	Male	Female	Total
White	247	171	418
Black	29	26	55
Asian	74	41	115
Hispanic	22	18	40
Middle Eastern	27	6	33
<b>Total</b>	<b>399</b>	<b>262</b>	<b>661</b>

Ethnicity Groups	W/O Augmentation			REWEIGHING			SMOTE			CHAMELEON		
	P	R	F1	P	R	F1	P	R	F1	P	R	F1
Overall	0.68	0.66	0.67	0.72	0.37	0.41	0.51	0.48	0.49	0.66	0.66	0.66
Black	0.40	0.13	0.20	0.30	0.43	0.36	0.11	0.13	0.12	0.40	0.74	0.52
Hispanic	0.05	0.02	0.03	0.07	0.12	0.09	0.03	0.06	0.04	0.10	0.12	0.11
Middle Eastern	0.00	0.00	0.00	0.14	0.86	0.24	0.09	0.07	0.08	0.40	0.29	0.33

## Animals

Animal Type	W/O Augmentation			REWEIGHING			SMOTE			CHAMELEON			Real Images		
	P	R	F1	P	R	F1	P	R	F1	P	R	F1	P	R	F1
Overall	0.62	0.64	0.61	0.59	0.60	0.59	0.81	0.61	0.65	0.62	0.63	0.62	0.62	0.62	0.62
Cow	0.45	0.23	0.30	0.35	0.30	0.32	0.23	0.41	0.29	0.37	0.38	0.37	0.44	0.31	0.37
Sheep	0.50	0.25	0.33	0.40	0.30	0.34	0.12	0.91	0.21	0.33	0.45	0.38	0.54	0.39	0.45
Cat	0.33	0.01	0.02	0.31	0.02	0.03	0.13	0.17	0.15	0.44	0.23	0.30	0.34	0.30	0.32
Elephant	0.69	0.20	0.30	0.49	0.24	0.32	0.02	0.00	0.01	0.43	0.37	0.40	0.56	0.53	0.55