AxGames: Towards Crowdsourcing Quality Target Determination in Approximate Computing

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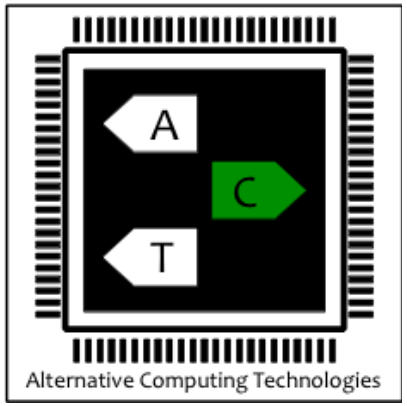
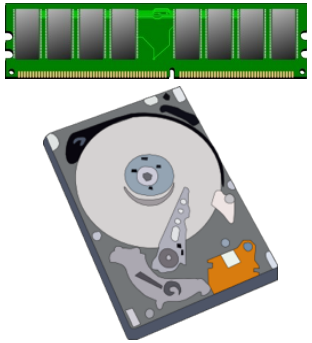


Approximate computing

Embracing imprecision

Relax the abstraction of ***"near perfect"*** **accuracy in**

Data Processing



Storage

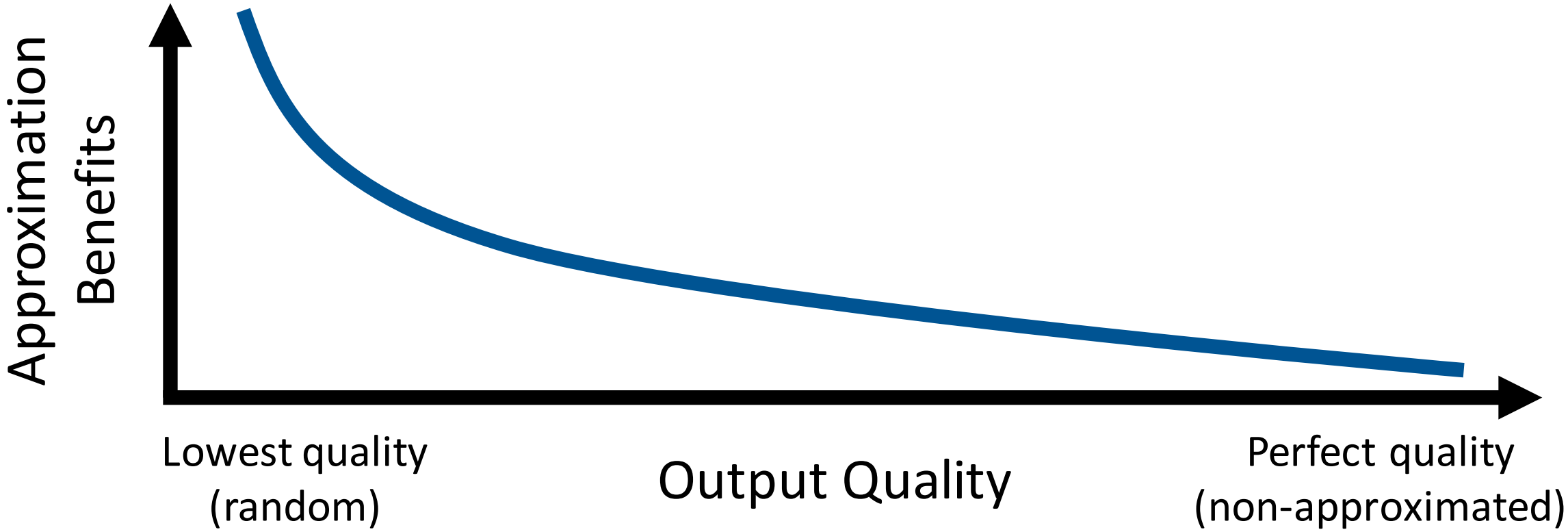
Communication

Accept **imprecision** to improve

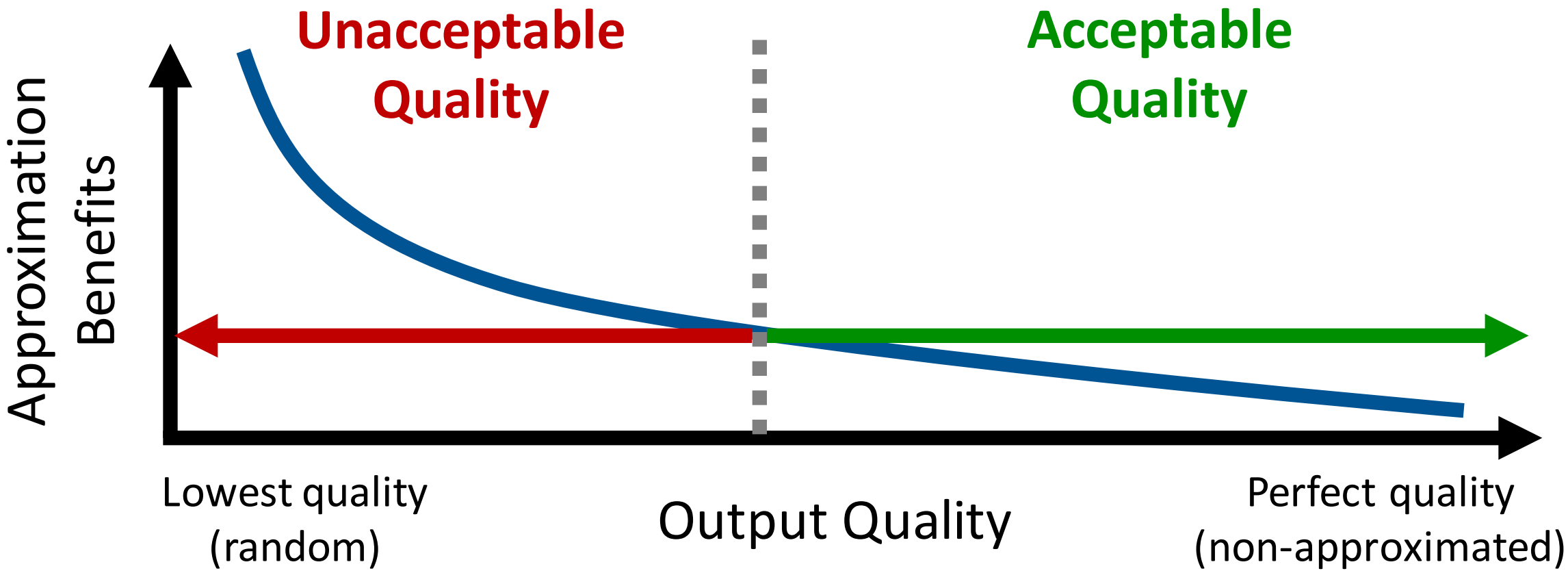
performance

energy efficiency

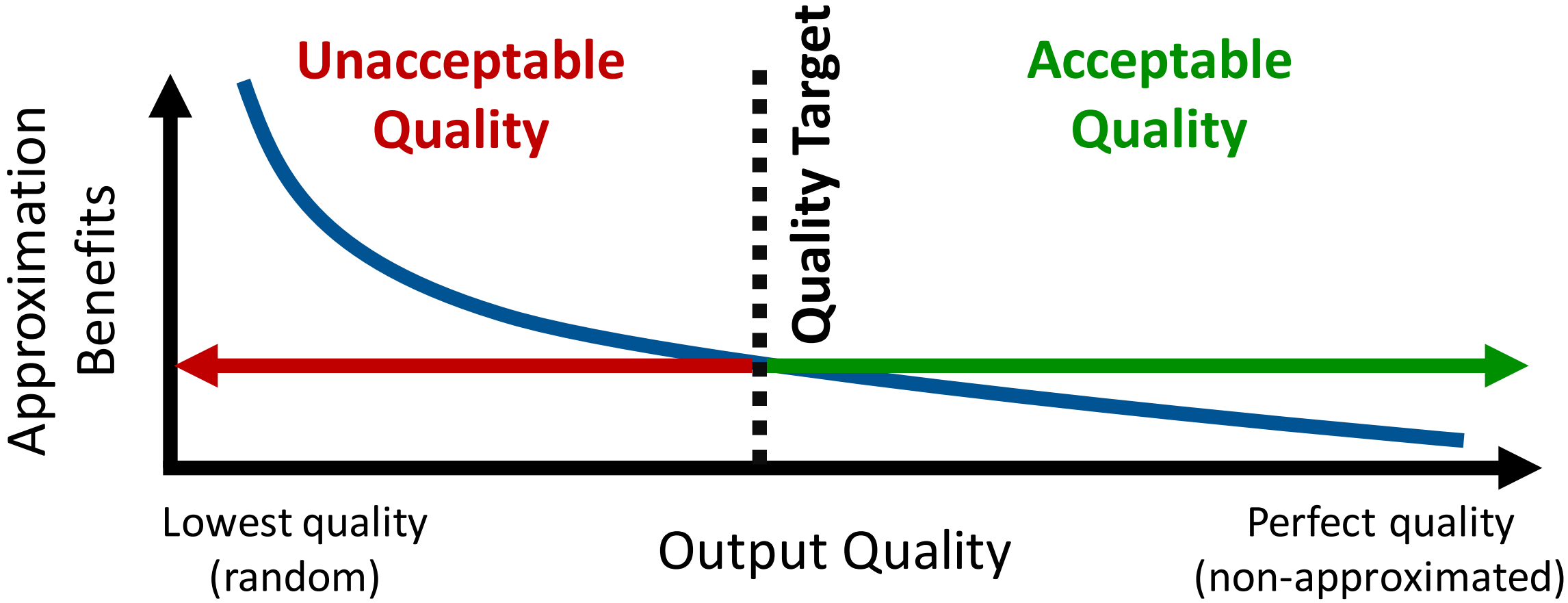
Tradeoff b/w quality and benefits



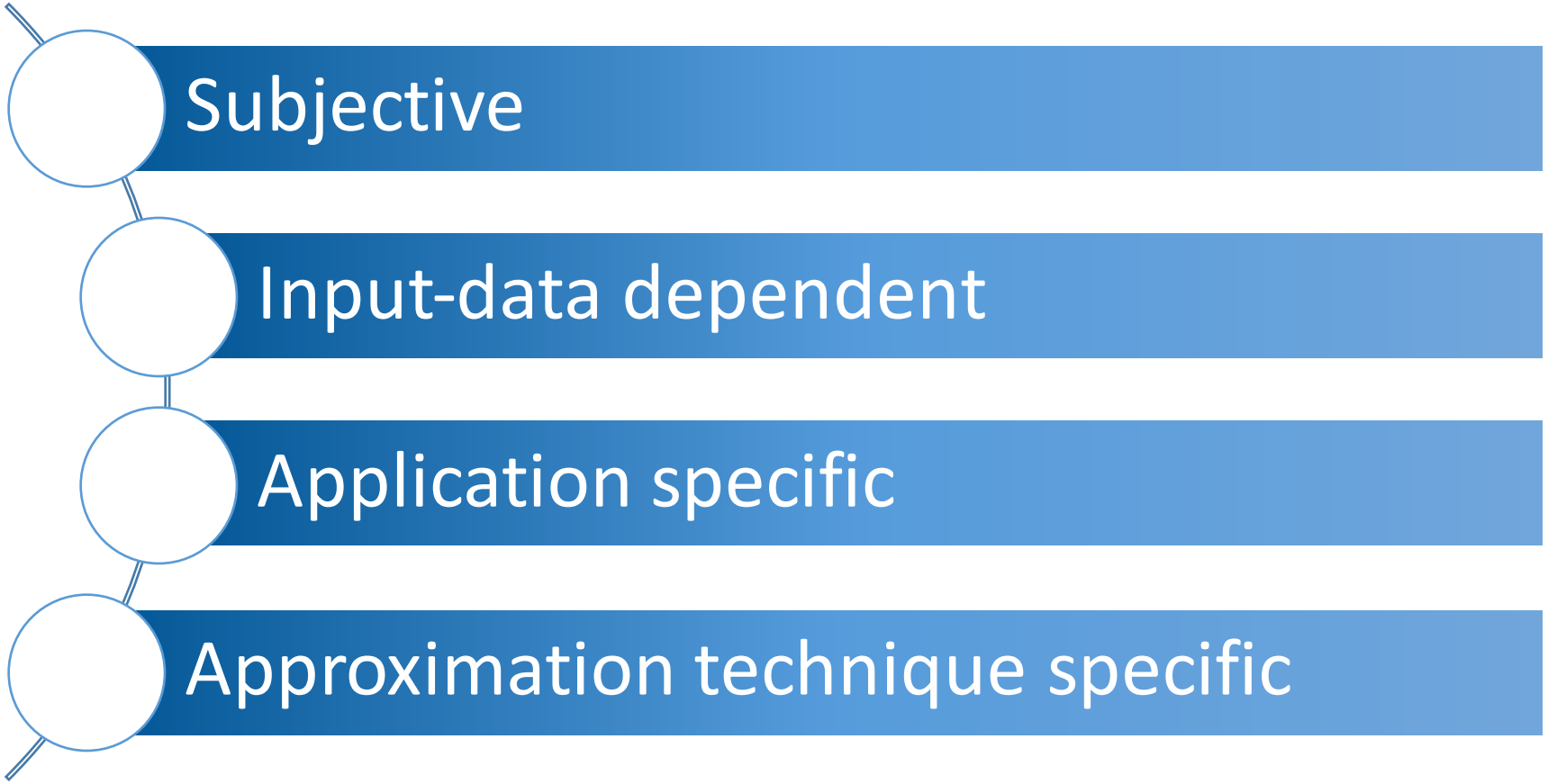
Tradeoff b/w quality and benefits



Tradeoff b/w quality and benefits

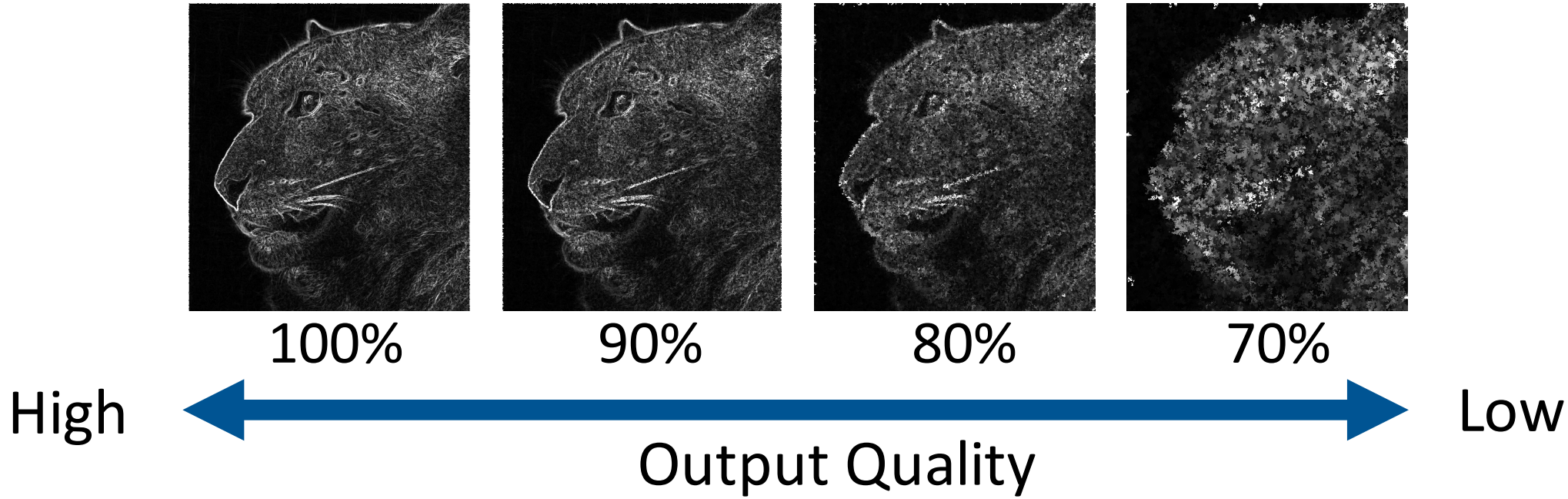


Acceptable quality is



Acceptable quality

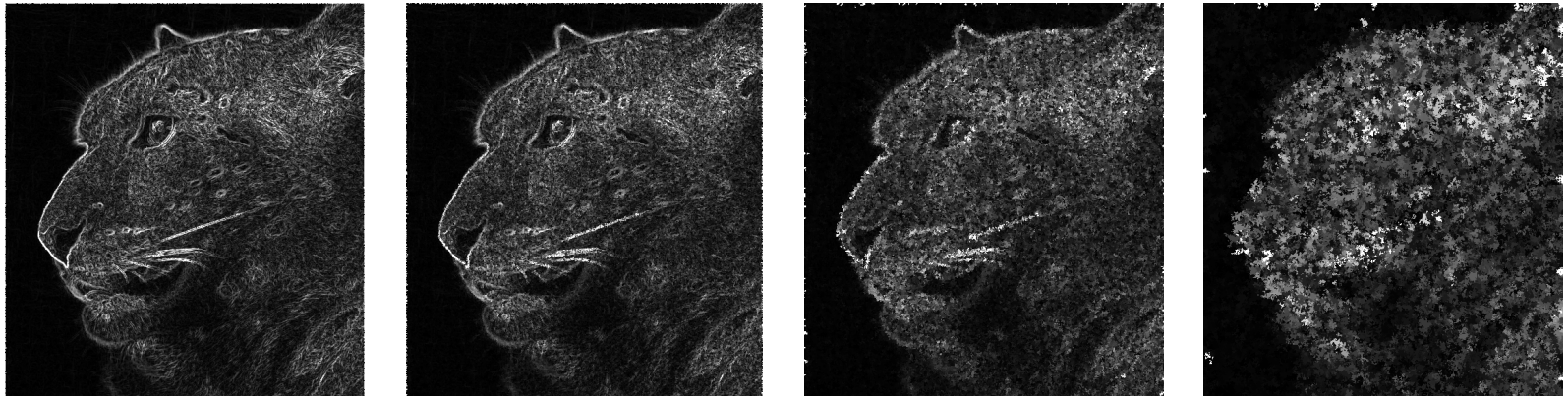
Subjective



Acceptable quality

Subjective

Which has the lowest acceptable quality?

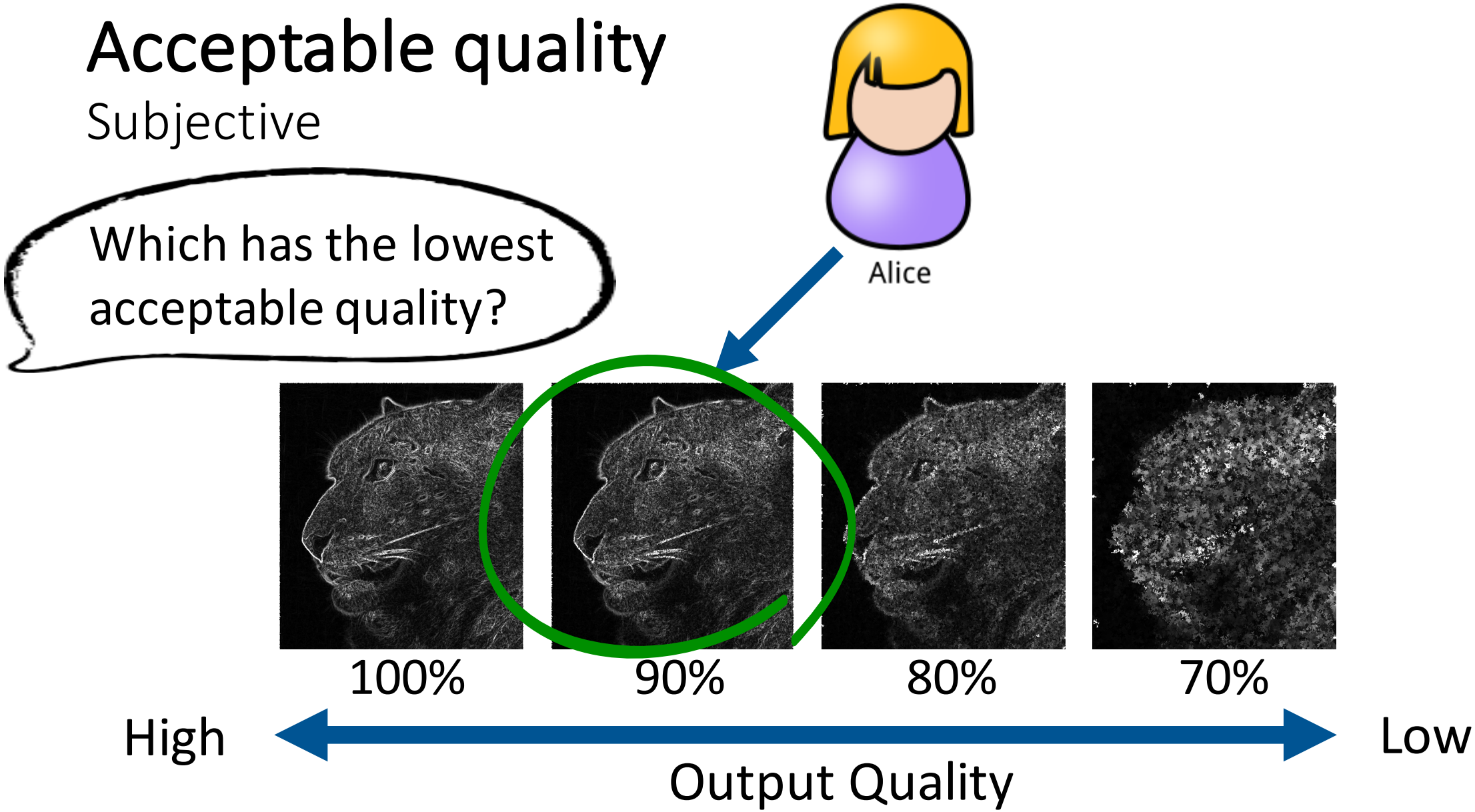


100% 90% 80% 70%

High ← Output Quality → Low

Acceptable quality

Subjective



Acceptable quality

Subjective

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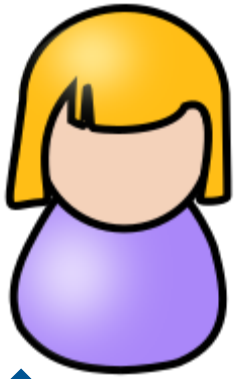
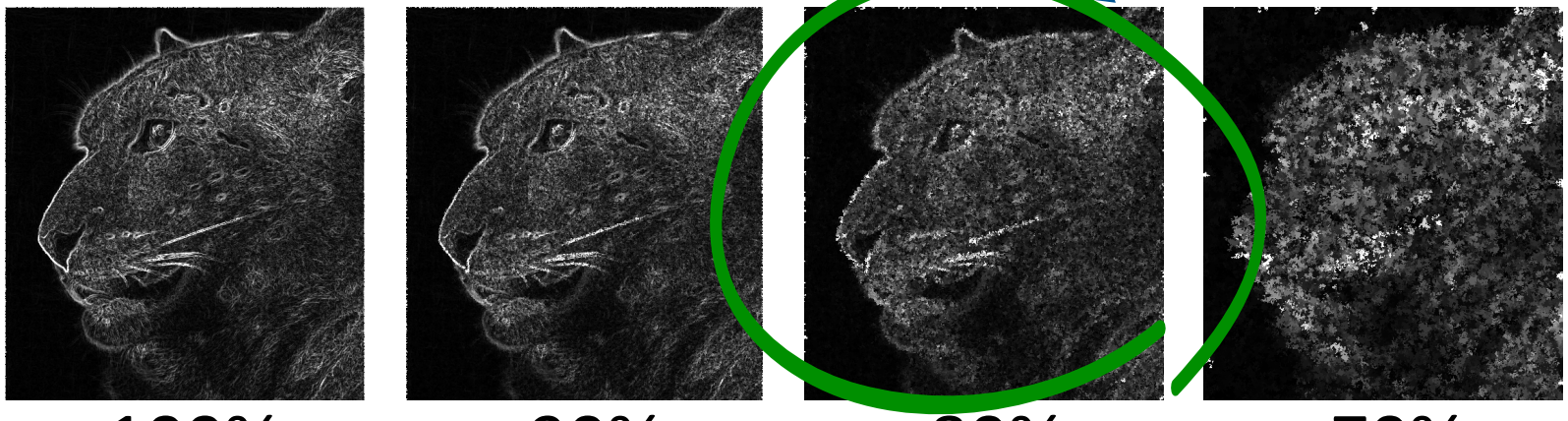


Alice

Bob

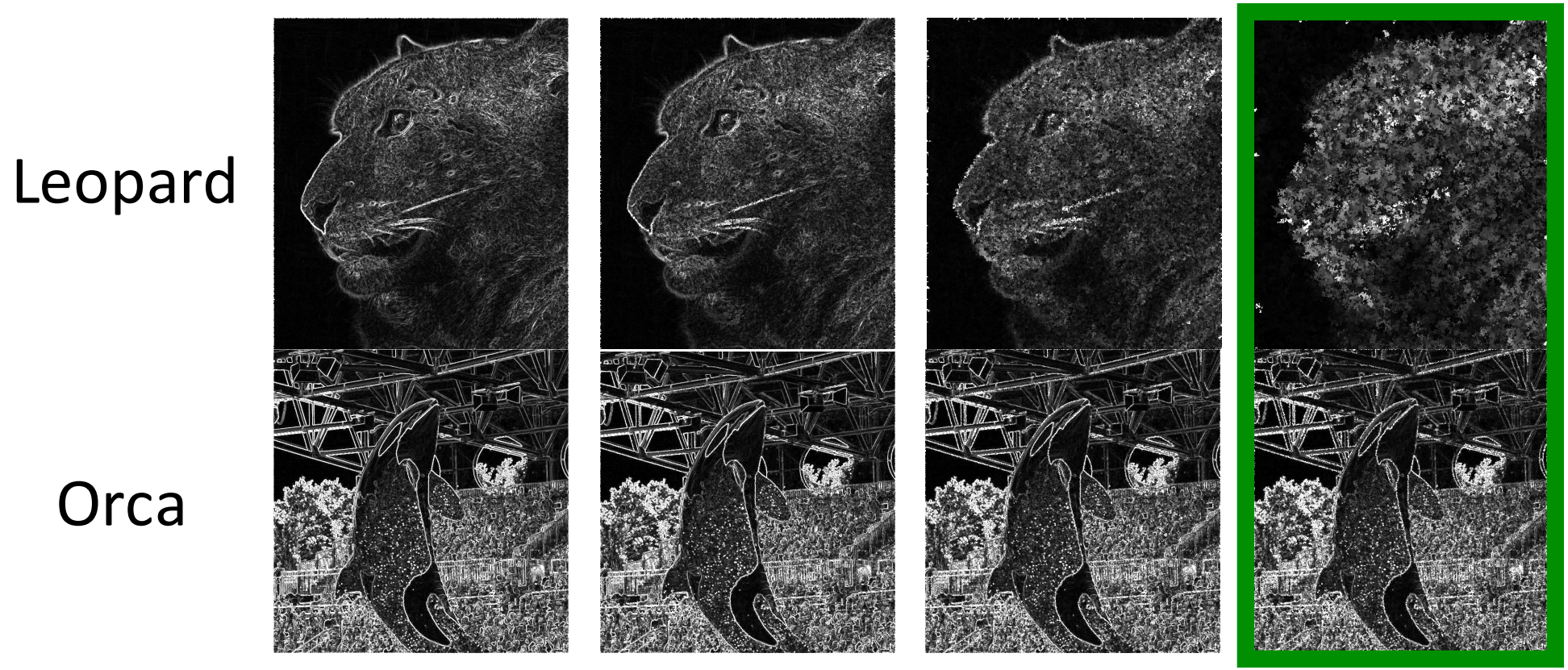


100% 90% 80% 70%

High ← Output Quality → Low

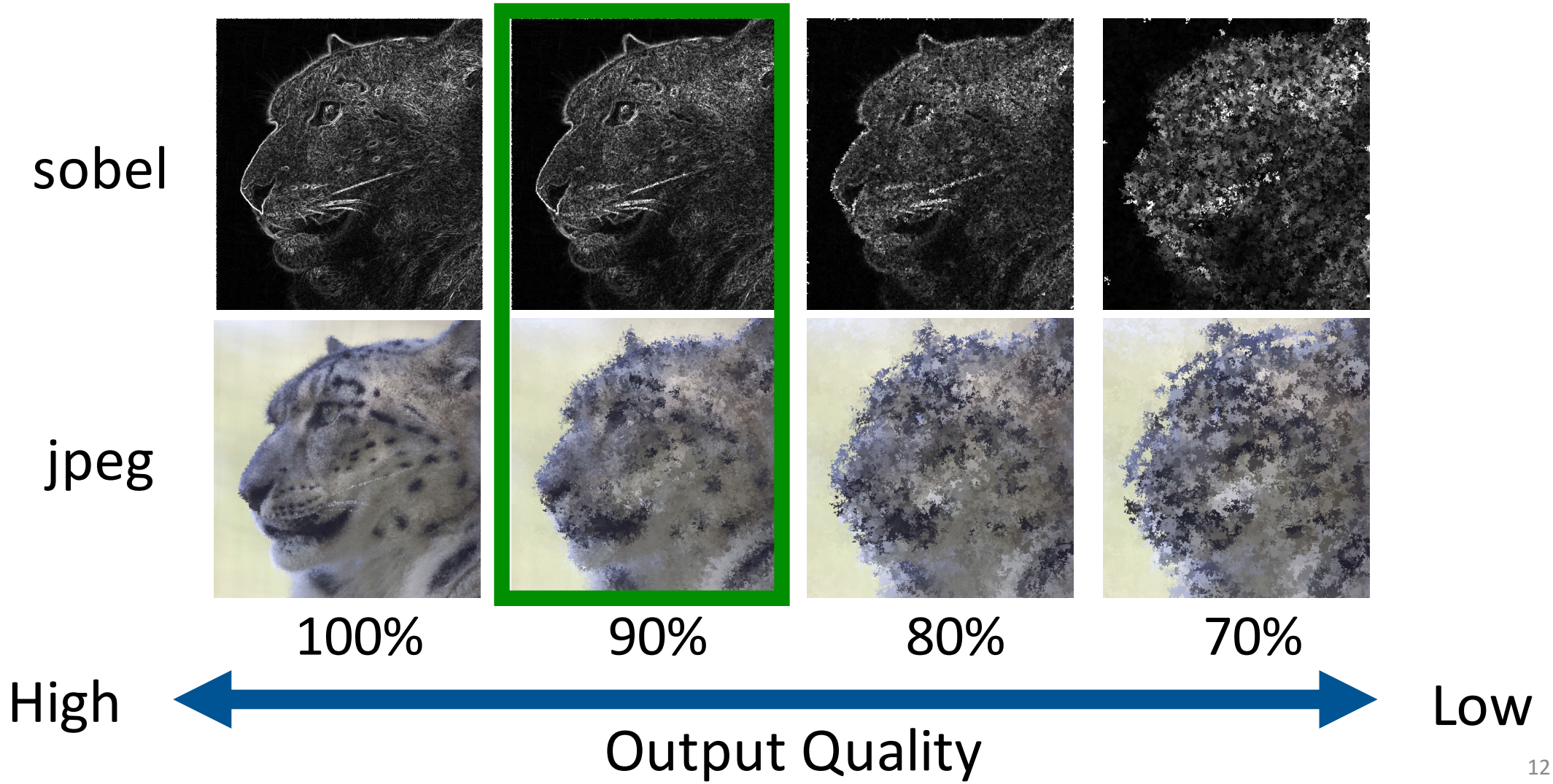
Acceptable quality

Input data dependent



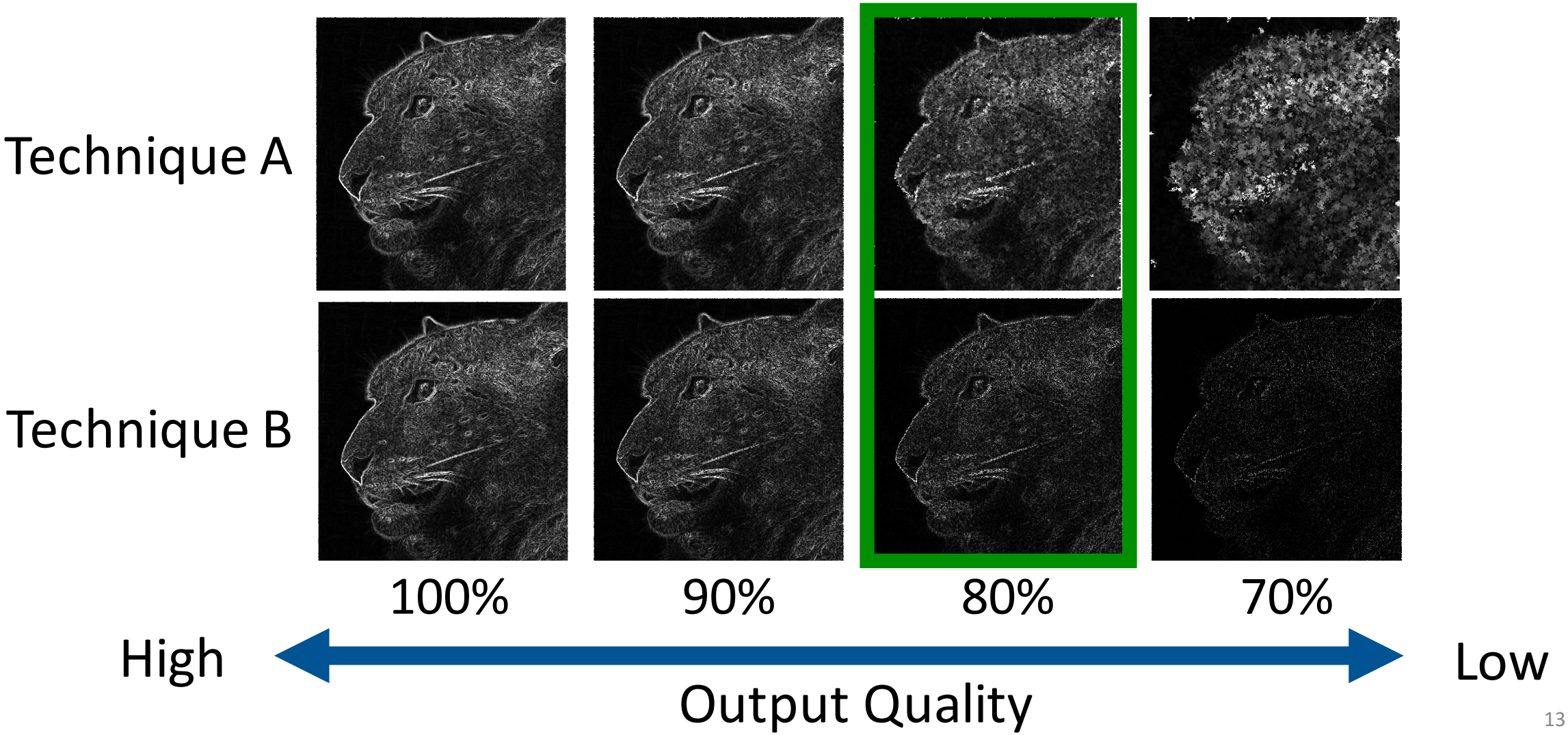
Acceptable quality

Application specific



Acceptable quality

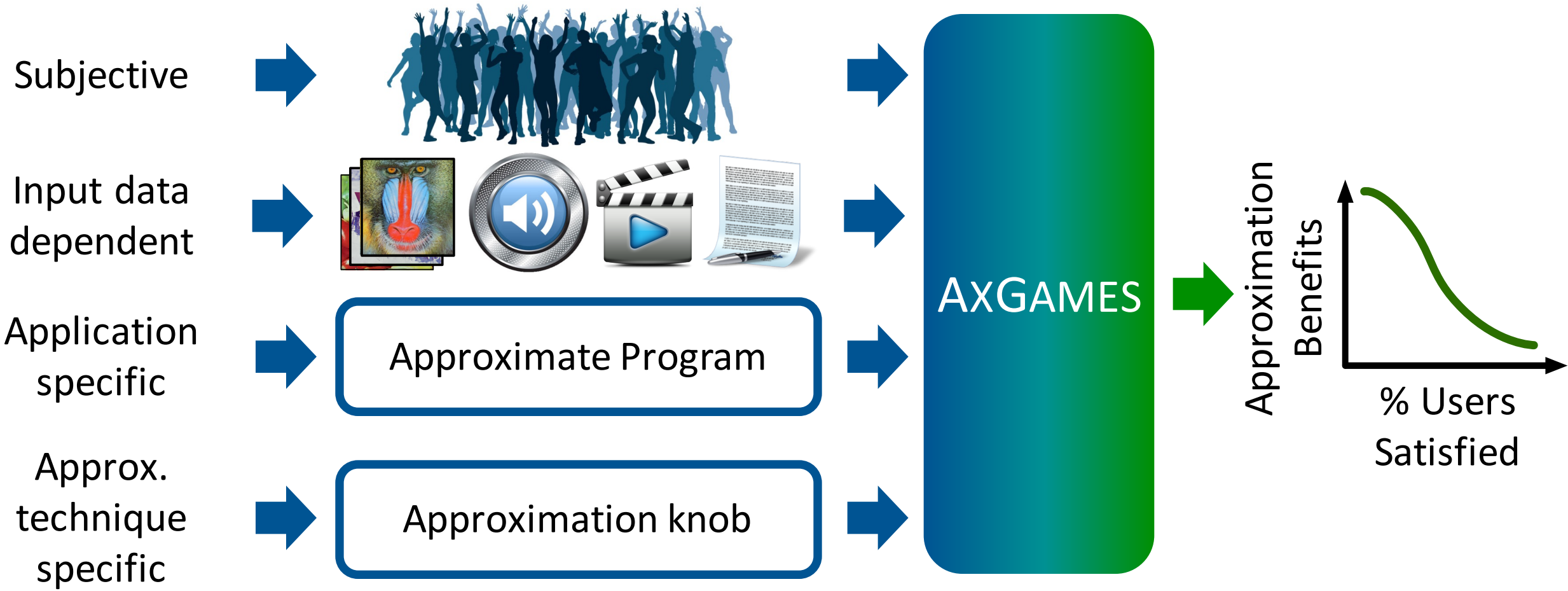
Approximation technique specific



AxGames

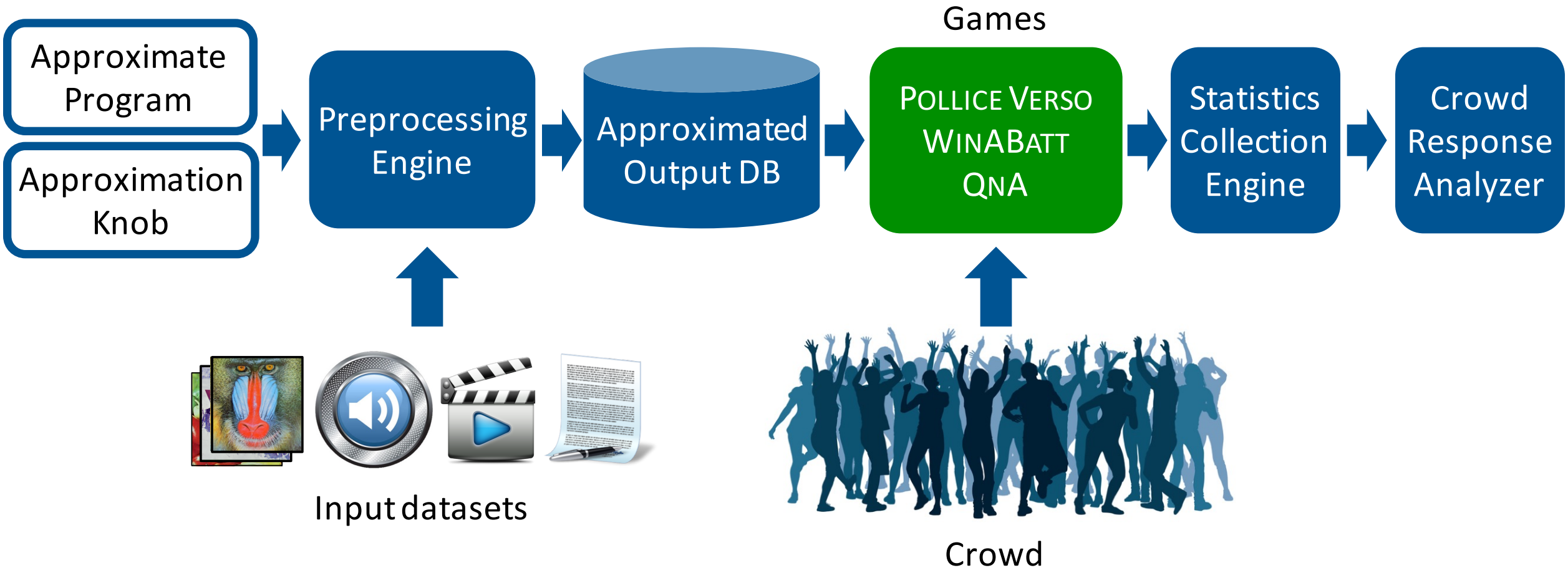
Transforming the tradeoff in approximate computing

AxGames: systematic and general framework



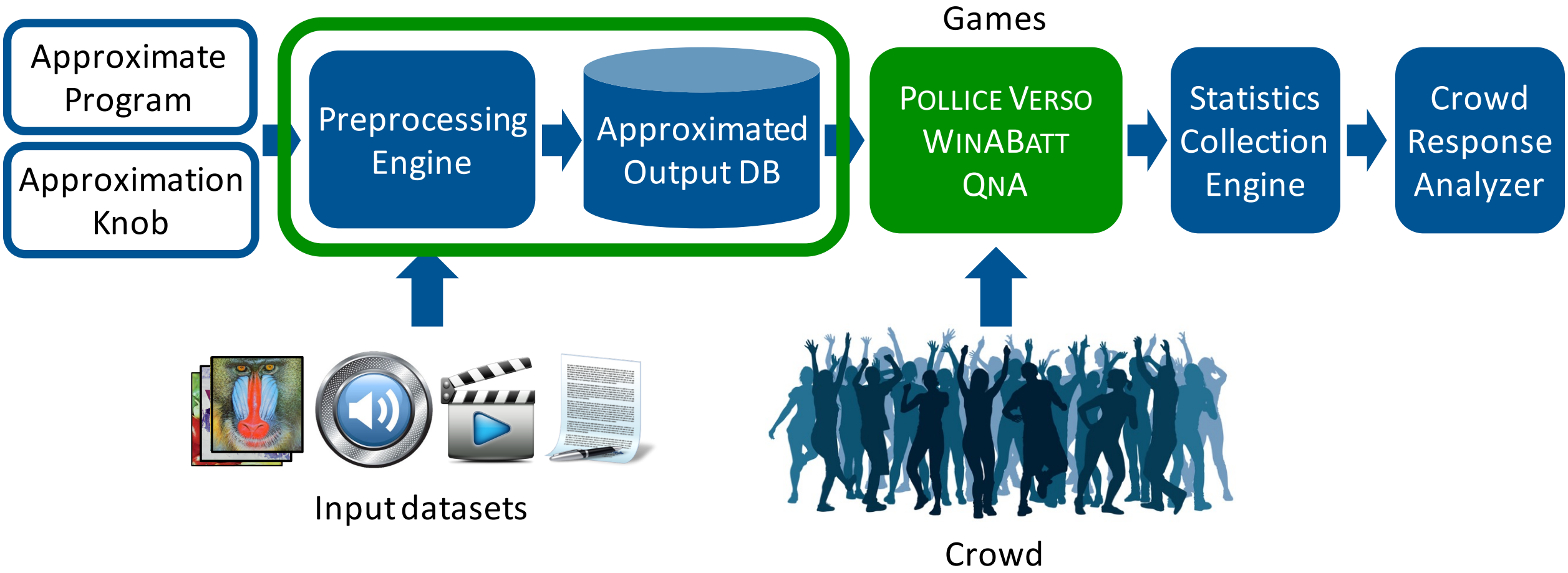
AxGames

A systematic solution for quality target determination



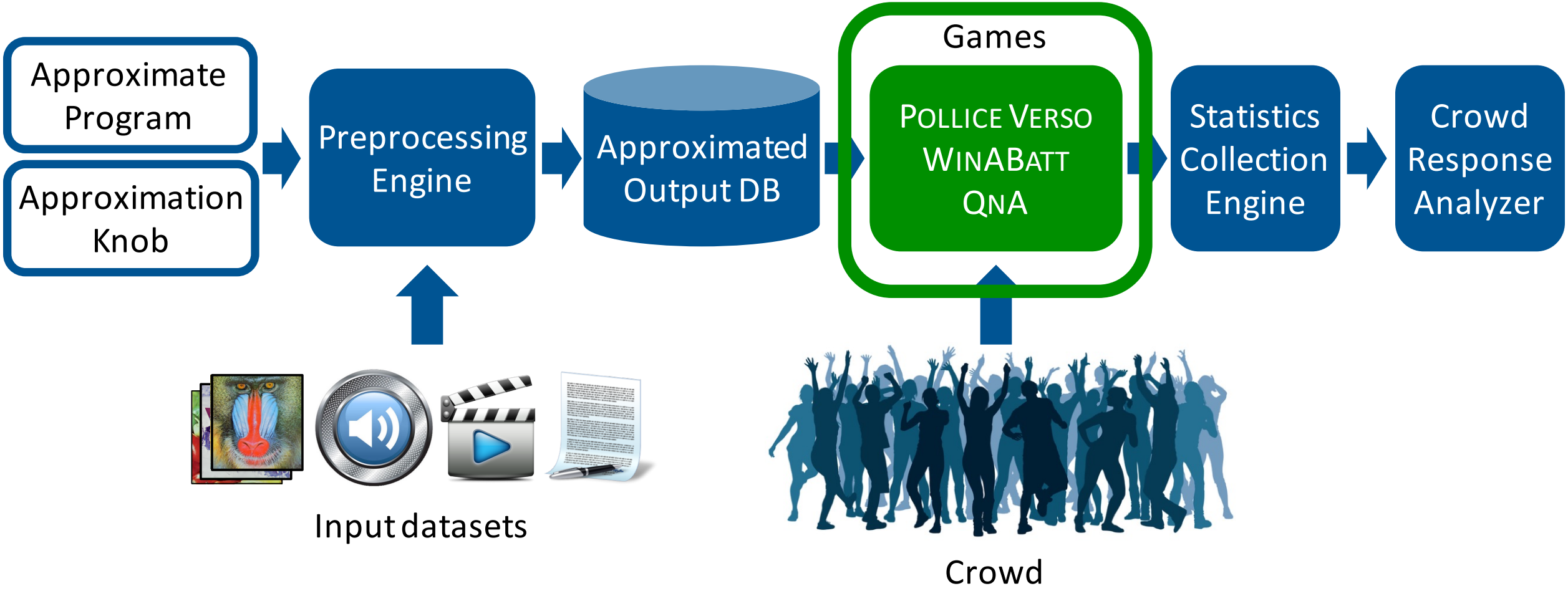
AxGames

A systematic solution for quality target determination



AxGames

A systematic solution for quality target determination



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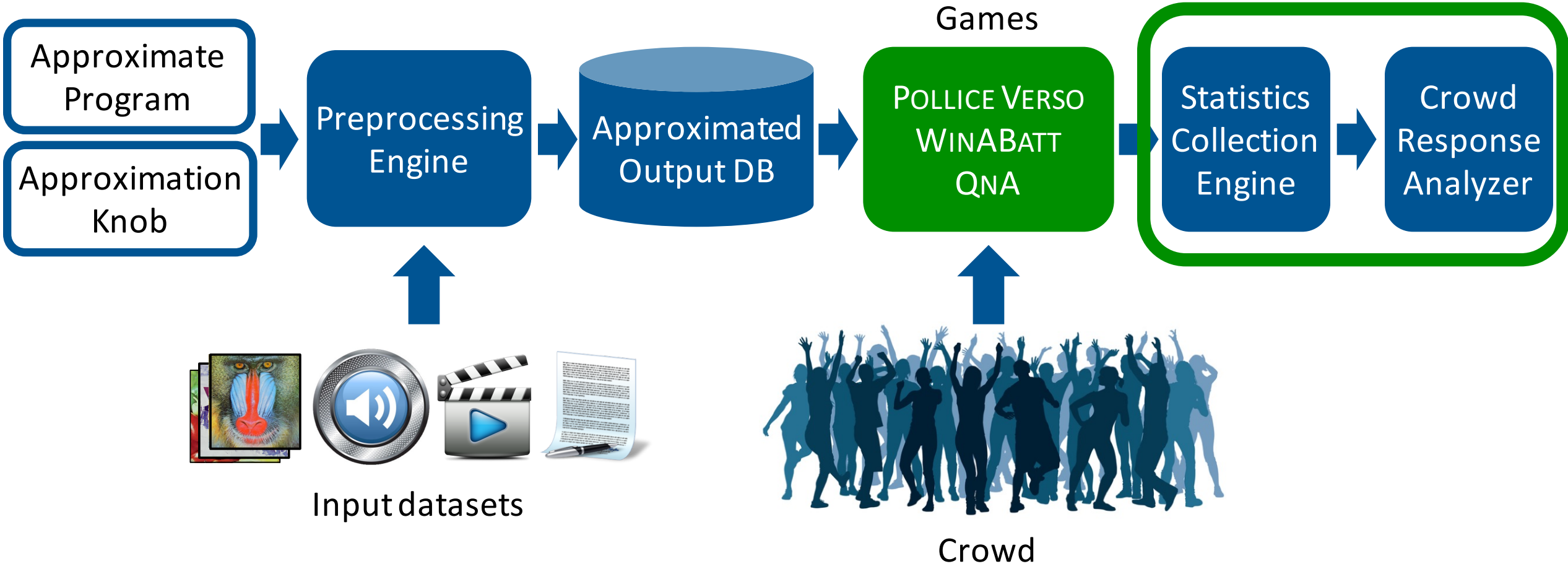

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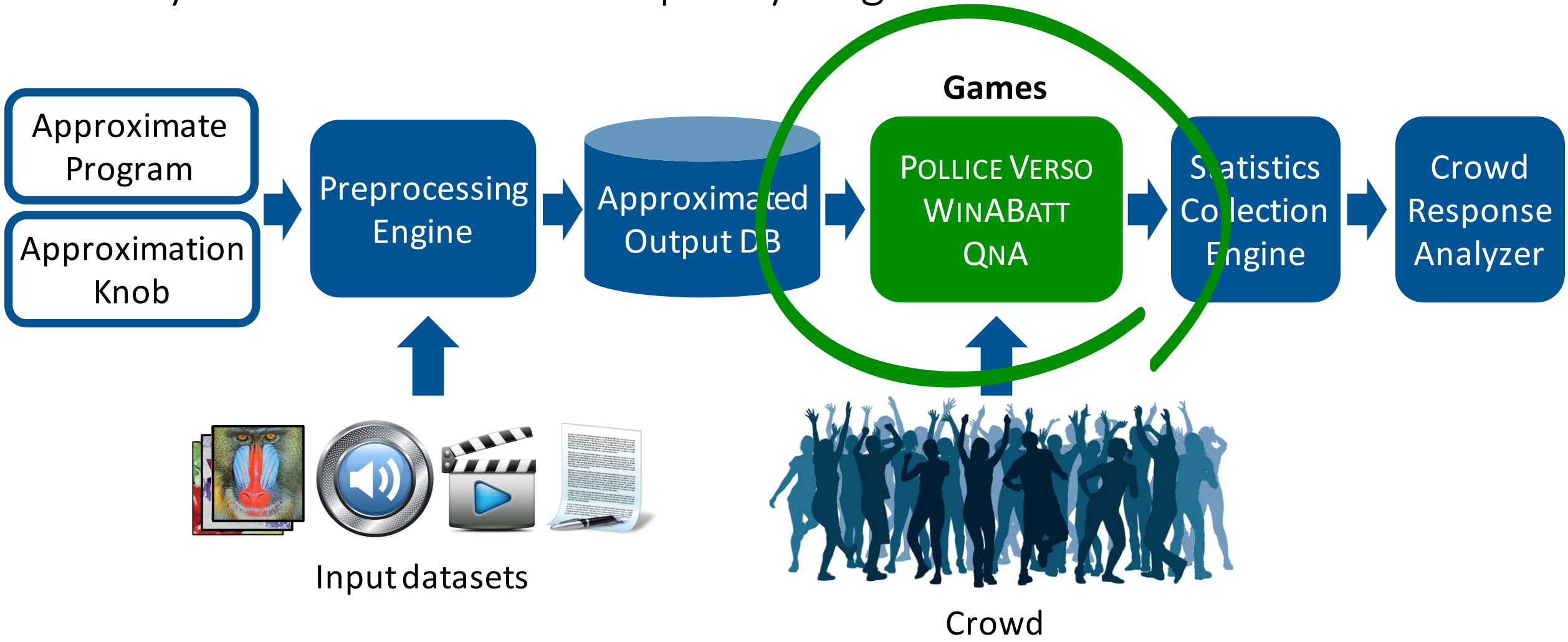

Three games

Research questions to be answered

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1. How much quality loss would the crowd accept? → **POLLICE VERSO**

Three games

Research questions to be answered

1. How much quality loss would the crowd accept? → **POLLICE VERSO**

2. How much quality loss would the crowd accept when quality-cost tradeoff is considered? → **WINABATT**

Three games

Research questions to be answered

1. How much quality loss would the crowd accept? → **POLLICE VERSO**

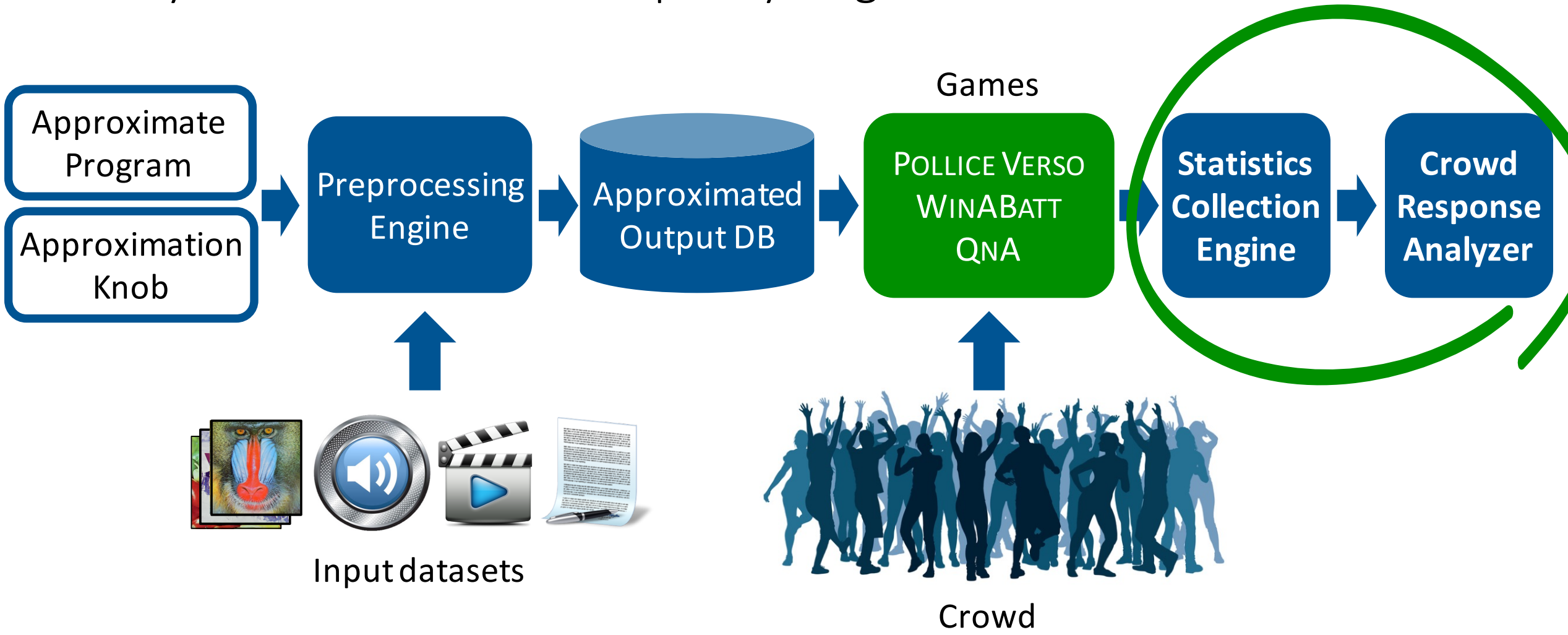
2. How much quality loss would the crowd accept when quality-cost tradeoff is considered? → **WINABATT**

3. How much quality loss would the crowd accept when quality-cost tradeoff and context of application are considered? → **QNA**

Let’s play!

AxGames

A systematic solution for quality target determination



Crowd response analyzer

Statistical analysis

Crowd response analyzer

Statistical analysis

Binomial Proportion Confidence Interval (Clopper-Pearson Exact Method)

$$(n_{trials}, n_{success}) \Rightarrow \frac{1}{1 + \frac{(n_{trials} - n_{success} + 1)}{n_{success} \times F[1-\alpha; 2n_{success}, 2(n_{trials} - n_{success} + 1)]}} < SuccessRate$$

$$with\ a\ confidence\ level$$

Crowd response analyzer

Statistical analysis

Binomial Proportion Confidence Interval (Clopper-Pearson Exact Method)

$$(n_{trials}, n_{success}) \Rightarrow r < SuccessRate$$

$$with\ a\ confidence\ level$$

Crowd response analyzer

Statistical analysis

Binomial Proportion Confidence Interval (Clopper-Pearson Exact Method)

$(n_{trials}, n_{success})$ ➡ $r < SuccessRate$

$with\ a\ confidence\ level$

E.g., (100, 80) ➡ 72.28% < SuccessRate

with 95% confidence level

Crowd response analyzer

Statistical analysis

$Quality\ q$

$(n_{Votes}, n_{GoodEnough})$

$\boldsymbol{r < \%\ Users\ Satisfied}$

Crowd response analyzer

Statistical analysis

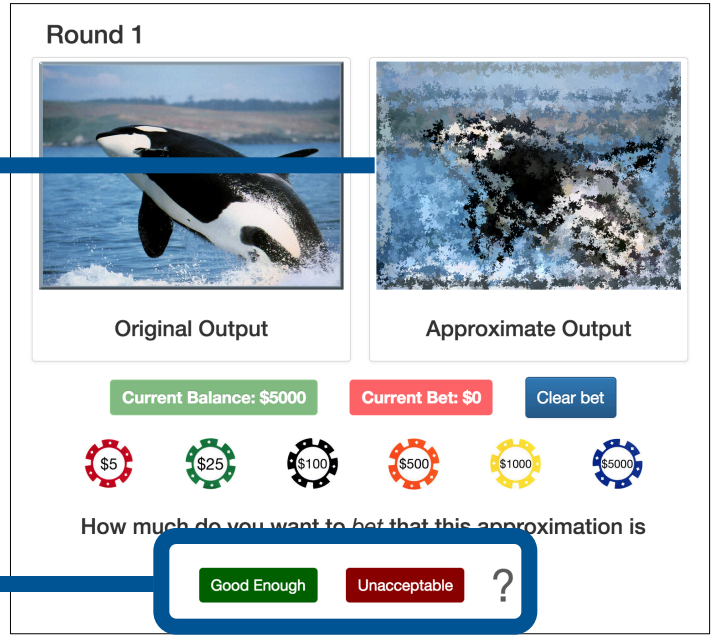
$Quality\ q$

$(n_{Votes}, n_{GoodEnough})$

$r < \%\ Users\ Satisfied$

70%

(1000, 634)



60.82% < % Users Satisfied

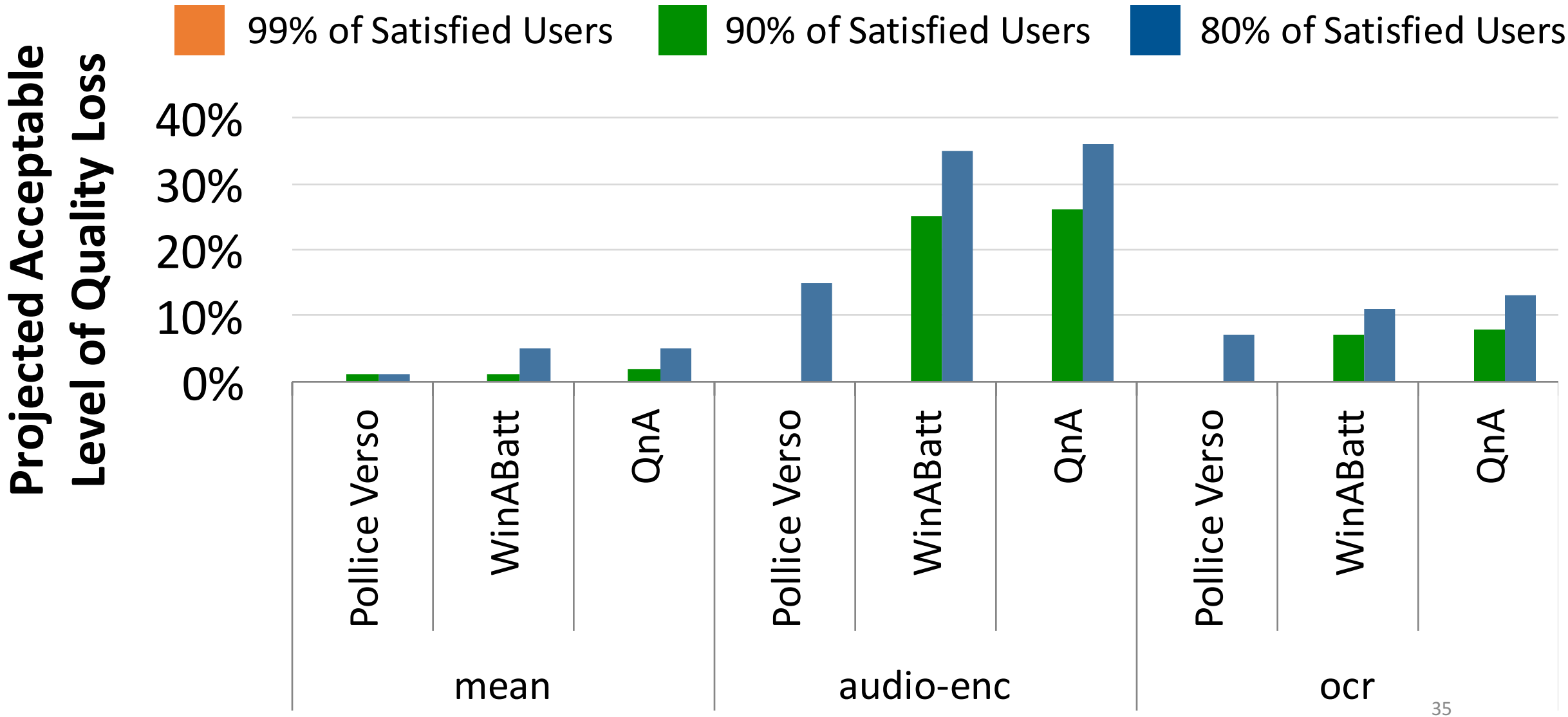
Benchmark

Benchmarks	Description	Quality Metric
emboss Image processing	Embossing filter	Normalized Root Mean Square Error (NRMSE)
jpeg Image processing	Lossy compression	
mean Image processing	Blurring filter	
sobel Image processing	Edge detection	
audio-enc Audio processing	Audio encoder	
ocr Text recognition	Optical character recognition	Text Similarity Ratio
speech2txt Text recognition	Embossing filter	

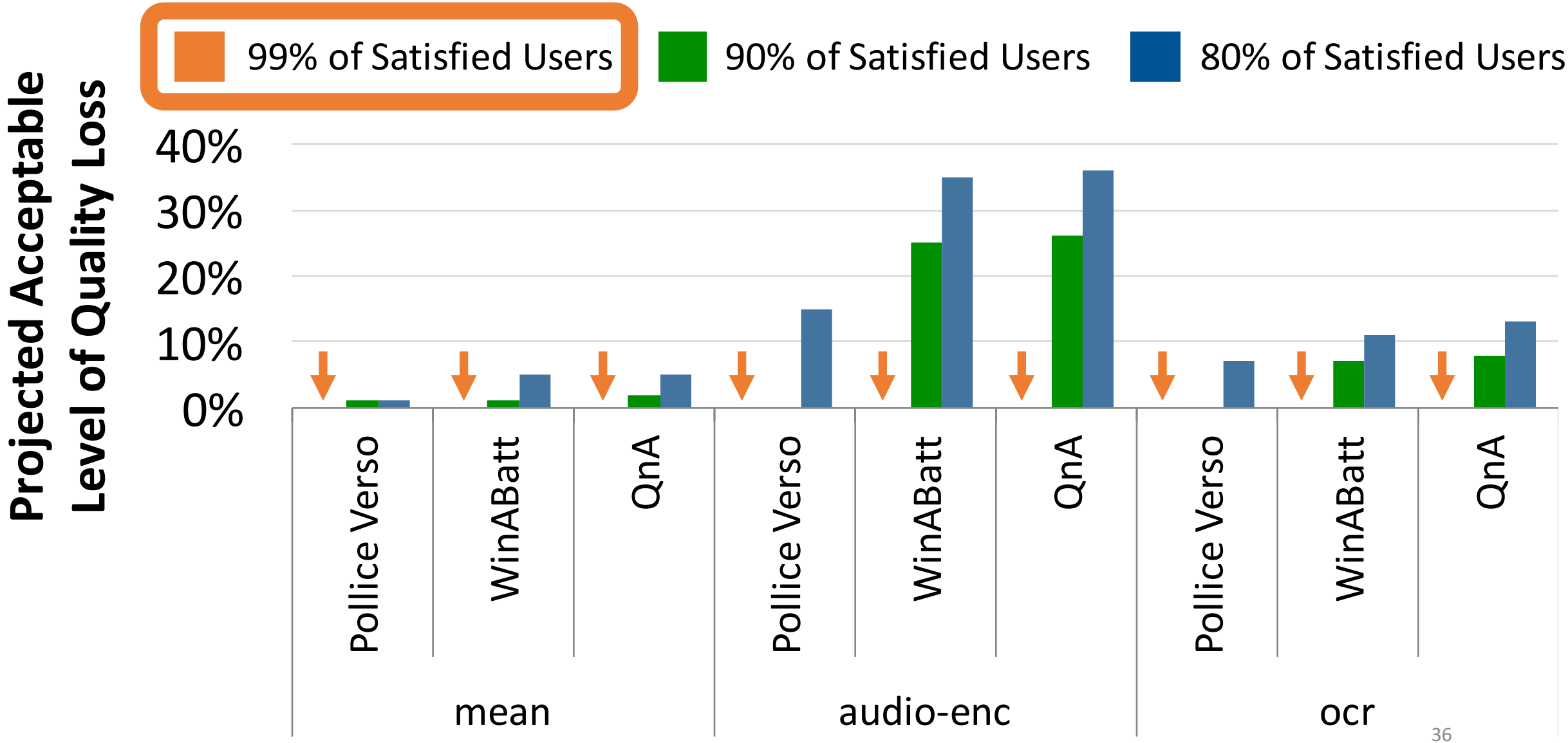
Crowd recruitment

700 Turkers for 7 benchmarks
30 rounds per player
(10 rounds per game)

Acceptable quality loss for applications/games



Acceptable quality loss for applications/games



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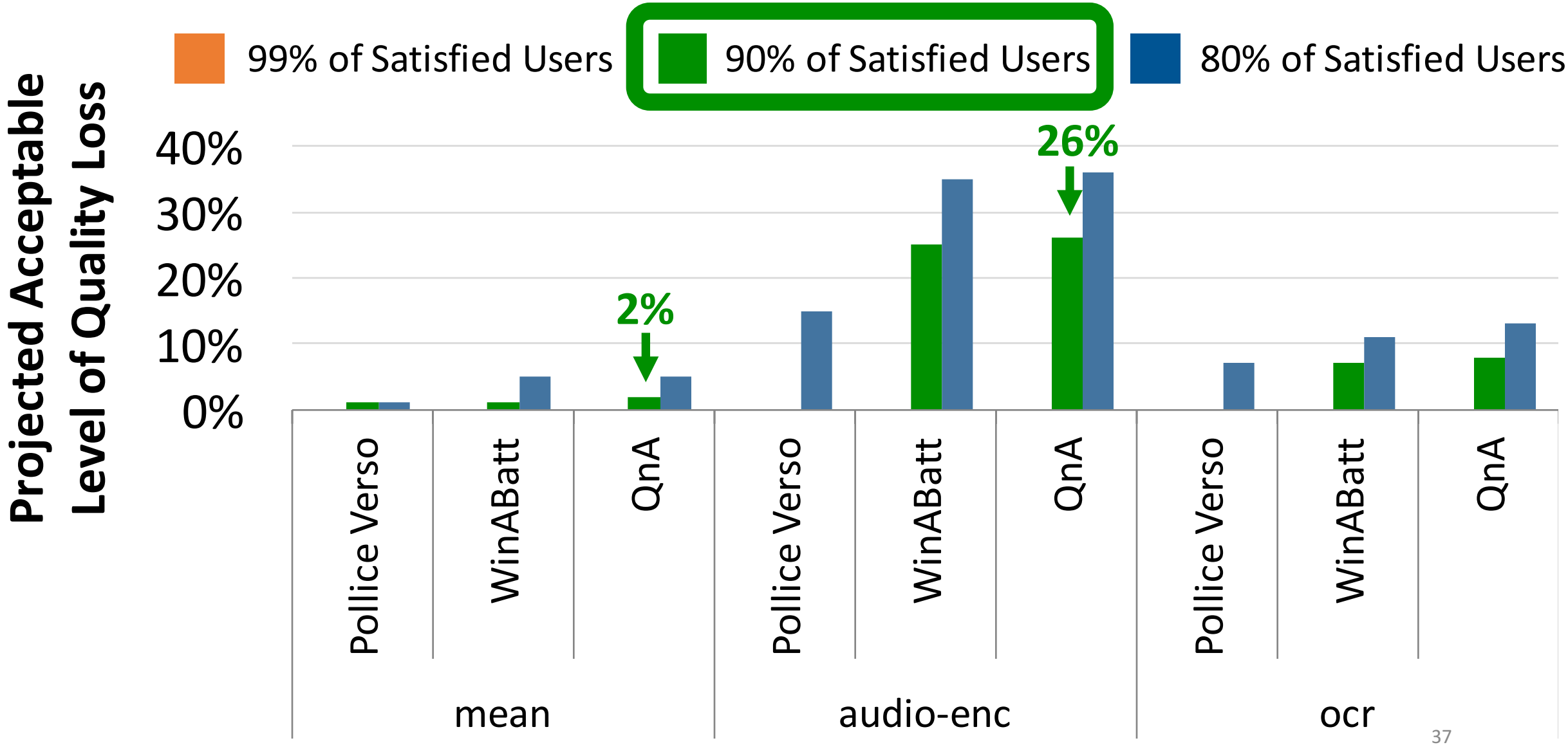
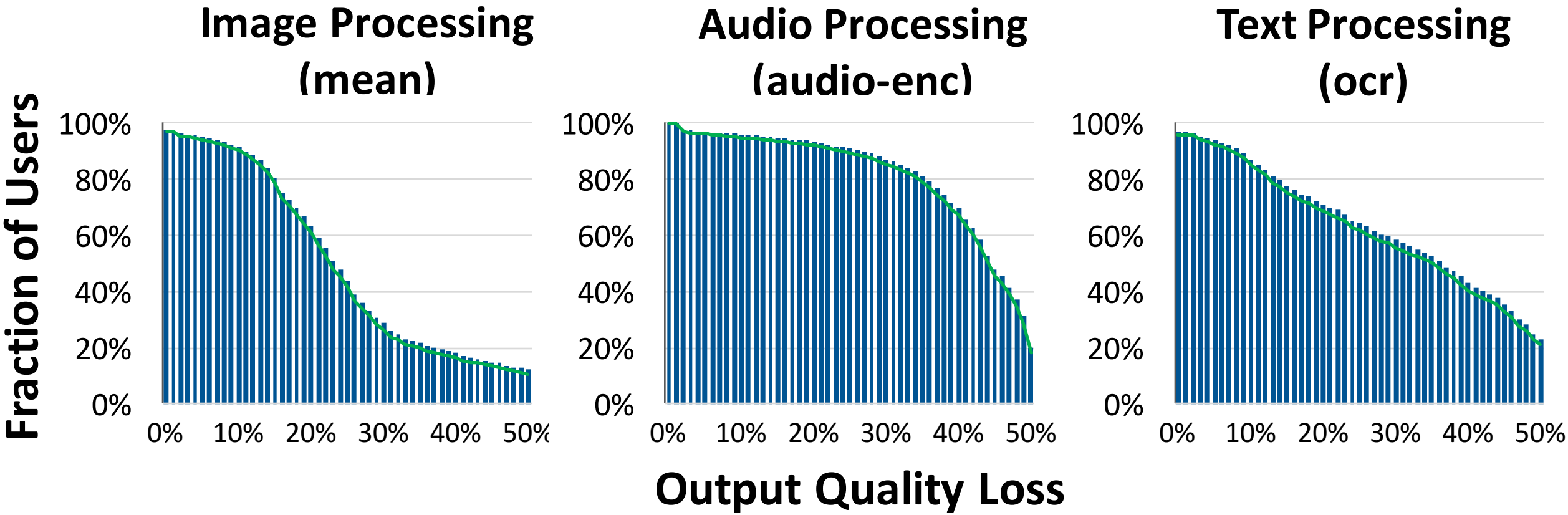


Different patterns for different domains

Projected fraction of satisfied users with 95% confidence level



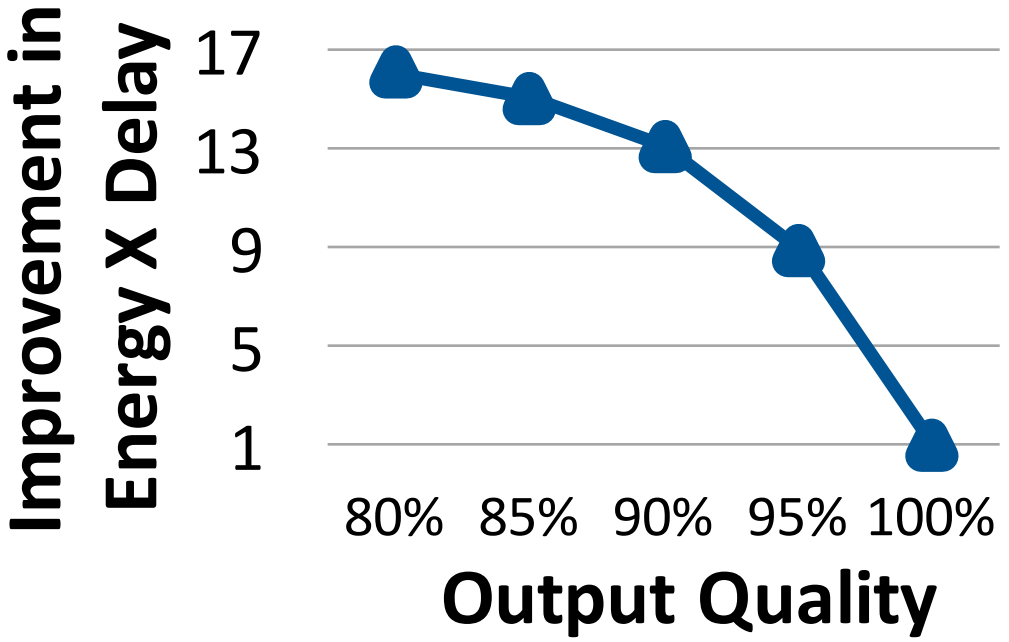
(statistics collected from the QNA game)

Tradeoff change in approximate computing

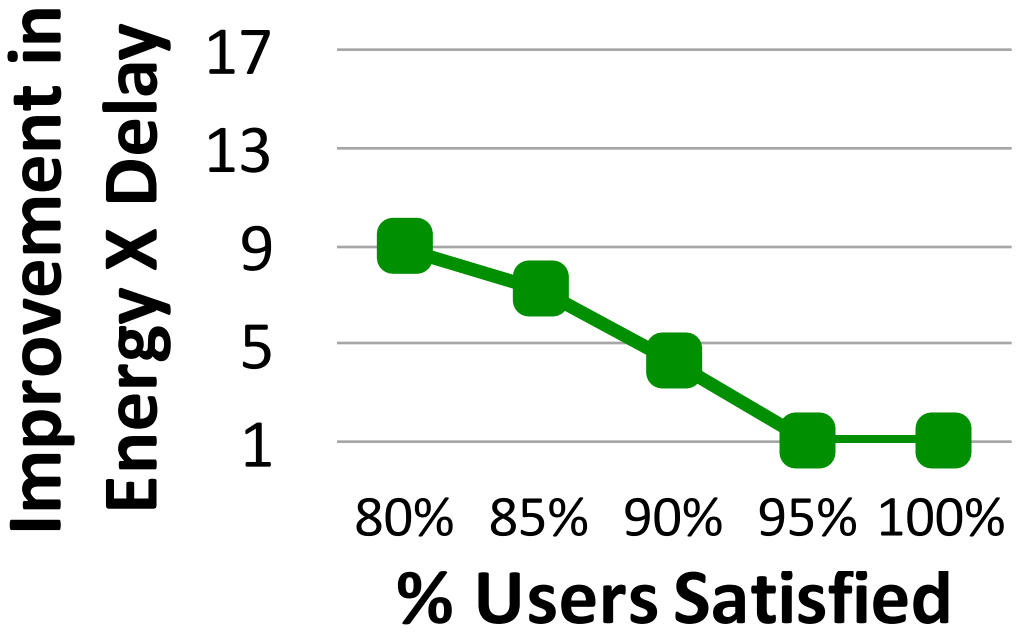
Example: mean

Tradeoff change from

quality vs. benefits to **user satisfaction vs. benefits**



AxGames



AxGames

http://act-lab.org/artifacts/axgames/

https://bitbucket.org/act-lab/game.code