

# 2018 MediFor Challenge

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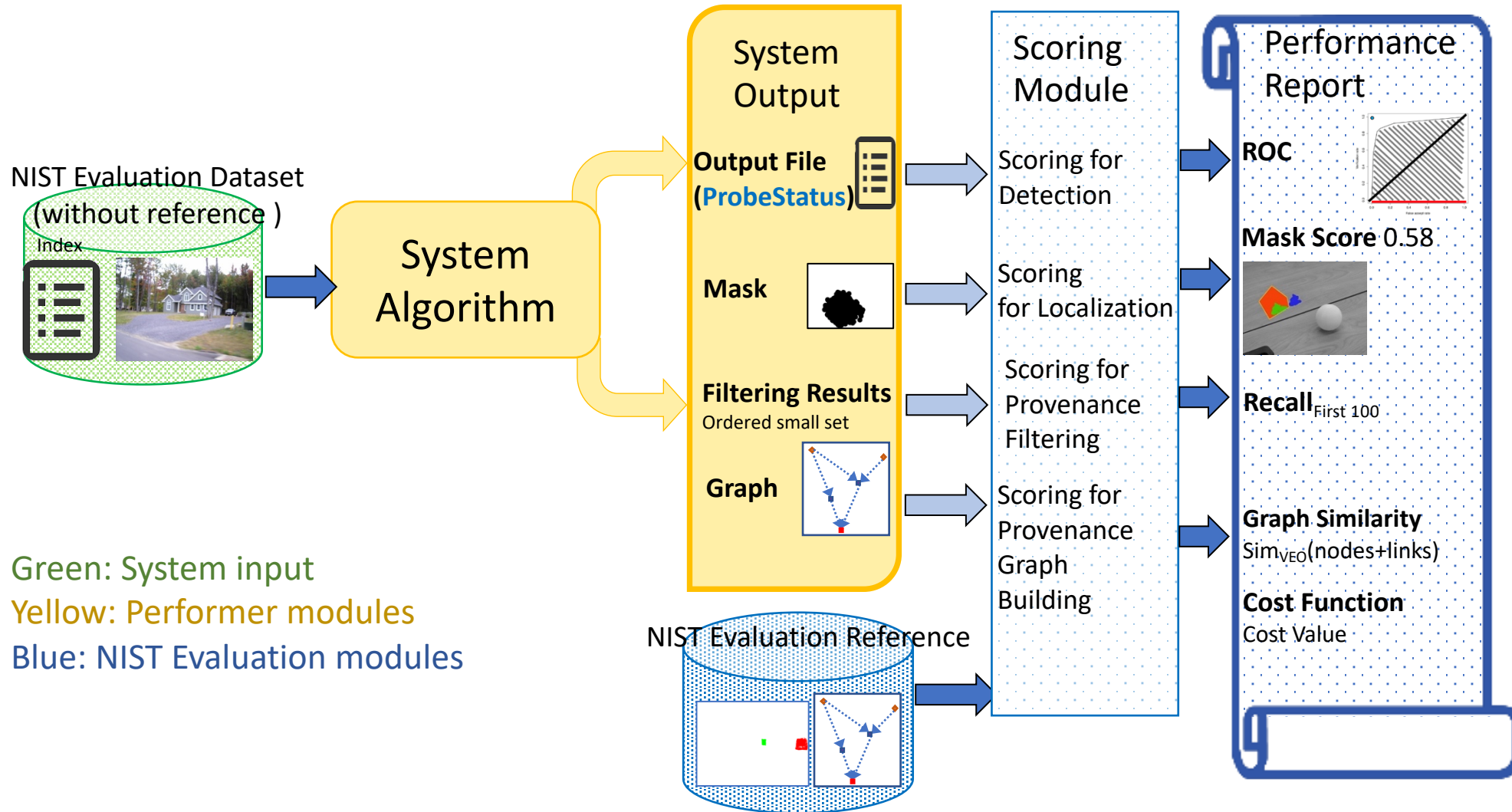
Information Technology Laboratory

National Institute of Standards and Technology (NIST)

# Outline

- MediFor Evaluation Tasks
- MediFor Data Sets
- NIST Evaluation Software: MediScore
- NIST Evaluation Scoring Server

# MediFor Evaluation Infrastructure

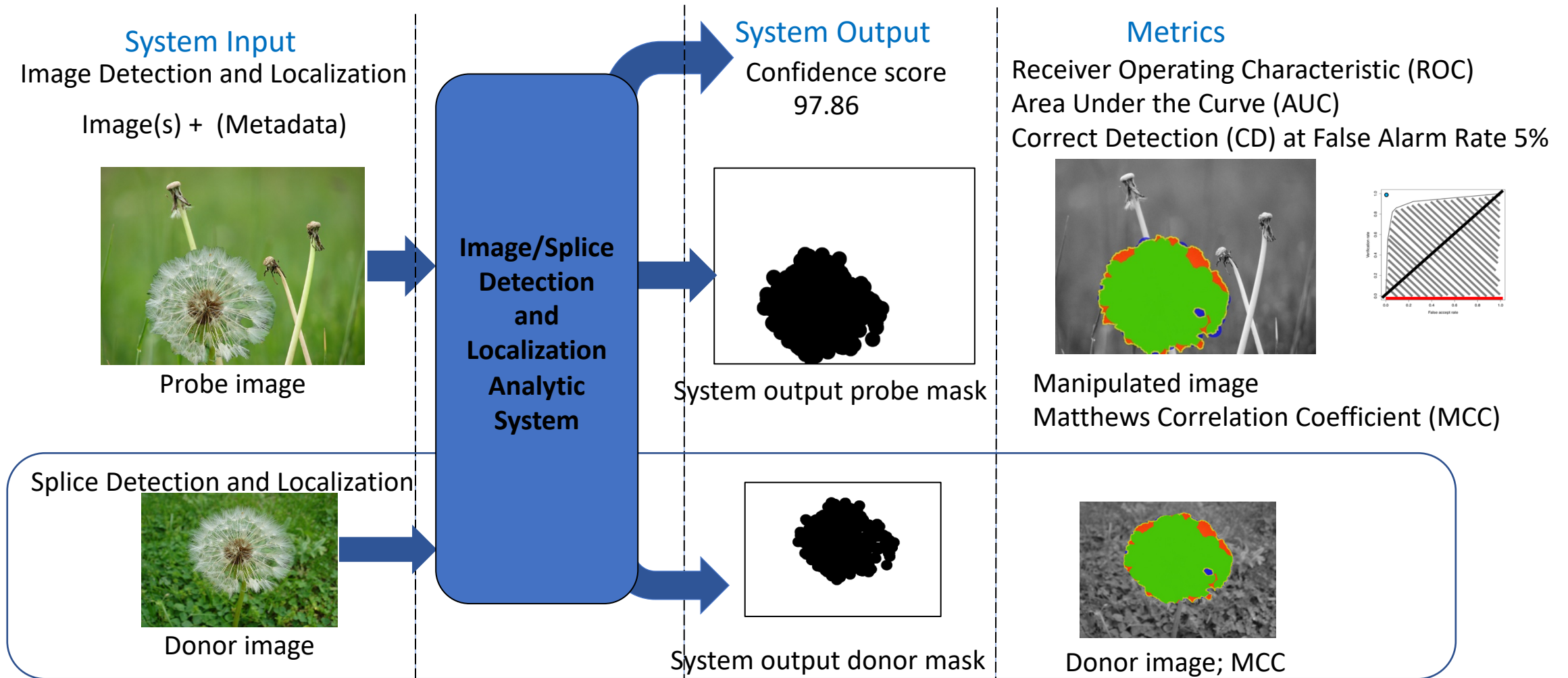


# Media Forensic Challenge (MFC) Evaluation Tasks

- Image Manipulation Detection
- Image Manipulation Localization
- Splice Detection and Localization
- Video Manipulation Detection
- Video Temporal Localization
- Provenance Filtering
- Provenance Graph Building
- Event Verification

# Image and Splice Manipulation Detection and Localization

(All images, graphs, and charts in all slides are original works created under contract on the MediFor Program)





# Video Manipulation Detection and Temporal Localization

- Video Detection metrics
  - Receiver Operating Characteristic (ROC)
  - Area Under the Curve (AUC)
  - Correct Detection (CD) at False Alarm Rate (FAR) of 5%
- Video Temporal Localization – Matthew Correlation Coefficient (MCC)

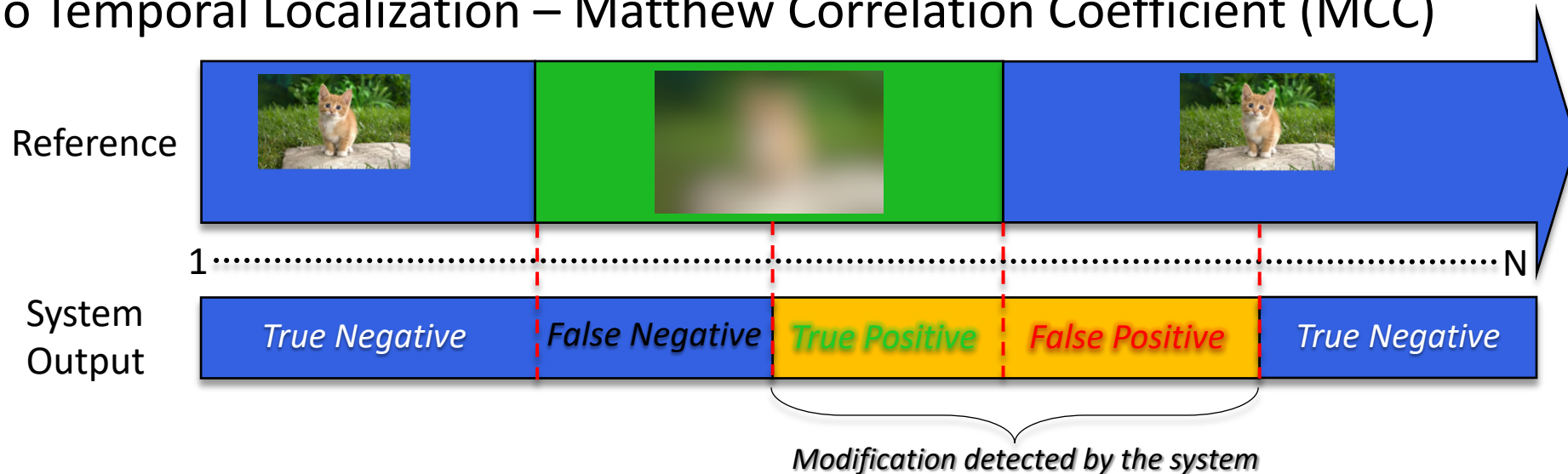
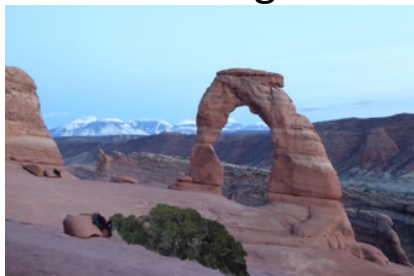


Figure: Video Temporal Detection and Localization

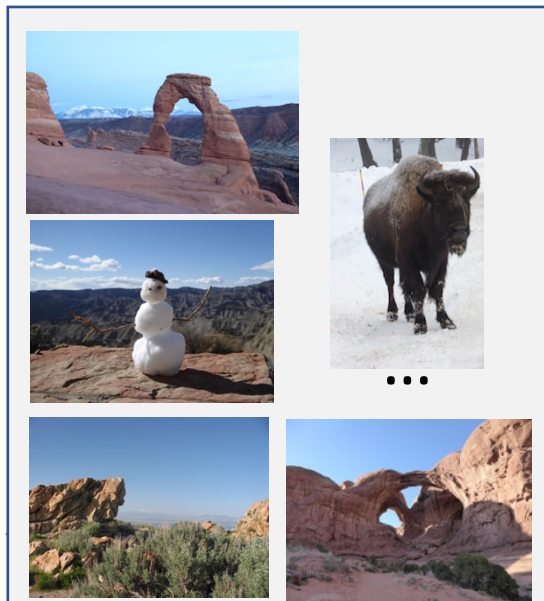
# Provenance Filtering and Graph Building

## System Input

Probe Image



- (1) **World Image Set** (a large collection of images from internet,  $\approx 1M$ )
- (2) **Oracle Set** (a small collection with all related nodes of the given probe,  $< 300$  for each probe)



Algorithm

## System Output

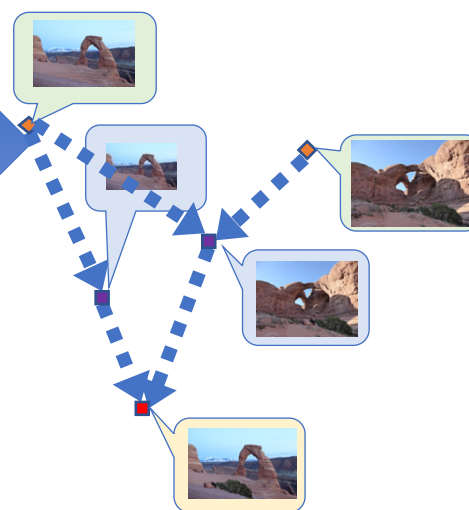
Filtering:

A set of N images with confidence score



Graph Building:

A provenance graph



## Metrics

Filtering:

Recall<sub>First 200/100/50</sub>

$$recall = \frac{|\{relevant\} \cap \{retrieved\}|}{|\{relevant\}|}$$

Graph Building:

Generalized F-measure:

$$\text{sim}_{\text{NLO}}(G_r, G_s) = 2 \frac{|V_r \cap V_s| + |E_r \cap E_s|}{|V_r| + |V_s| + |E_r| + |E_s|}$$

# Event Verification (1)

- Task Definition: Given a collection of images and videos from the event, determine if a probe is from the claimed event.
- MFC18 Events
  - 12 events: 6 hurricane, 3 air show, 3 others

**hurricane\_matthew**, **Hurricane\_Sandy**, Hurricane\_Harvey, Hurricane\_Katrina, Hurricane\_Irma, Hurricane\_Ike, **oshkosh2011**, oshkosh2010, **berlin\_air\_show**, Berlin\_Marathon, Chinese\_New\_Year\_London\_2014, Chicago\_Blizzard\_2011.



oshkosh2011



oshkosh2010



Hurricane\_Katrina



Hurricane\_Ike



Berlin\_Marathon



Chicago\_Blizzard\_2011



# Event Verification (2)

- System Input
  - Image and event name pair
- Metrics
  - Receiver Operating Characteristic (ROC), Area Under the Curve (AUC)
  - Correct Detection (CD) at False Alarm Rate (FAR) of 5%
- Training Data
  - N ( $N \approx 200$ ) images for each events. 12 events in MFC18: 6 hurricane, 3 air show, 3 others
  - Test and Training images' camera IDs are different.
- Testing Data
  - M ( $N \approx 50$ ) images for each event, then cartesian production with all event name to create pairs.

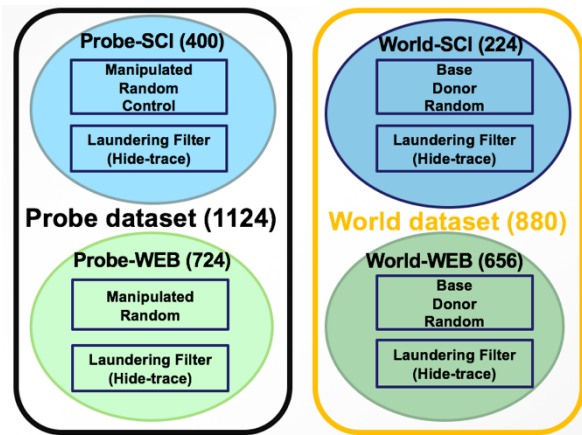
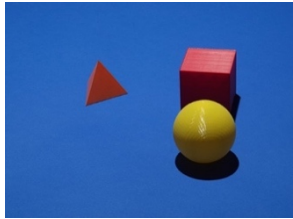
# Outline

- ✓ MediFor Evaluation Tasks
- MediFor Data Sets
  - NIST Evaluation Software: MediScore
  - NIST Evaluation Scoring Server

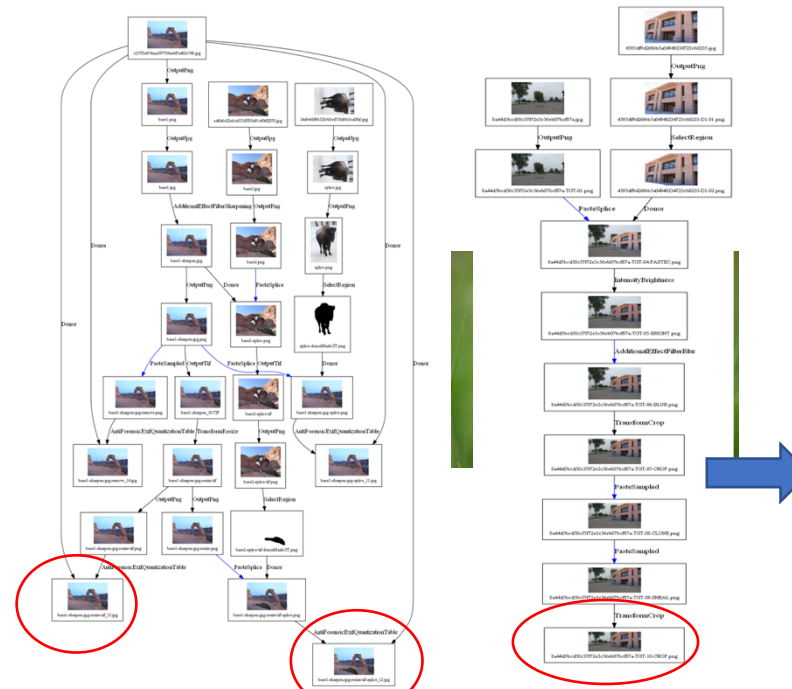
# Media Forensic Data Characteristics

- **Very diverse topics and tasks**
  - Close collaborations among DARPA, TA1, TA3, and NIST
  - Collection requirements: <https://mediforprogram.com/wiki/display/MEDIFOR/Year+2+Evaluation+and+Data+Needs>.
- **Active and generic online metadata collection**
  - Post ground-truth annotation is difficult or impossible.
  - The metadata was collected during the manipulation process with Journaling Tool – high cost.
  - Across different manipulation software and approaches.
- **High intrinsic dimensionalities**
  - Dimension space: image/video, metadata (EXIF, camera ID, captions, association among information units), manipulation (operations, filters, algorithms, and their history orders), semantic meaning.
  - Rich metadata are collected, annotated, recorded, selected, and sampled for evaluation analysis.
- **Data release control mechanism**
  - Camera selection
  - Training and testing data selection
  - Evaluation dataset generation

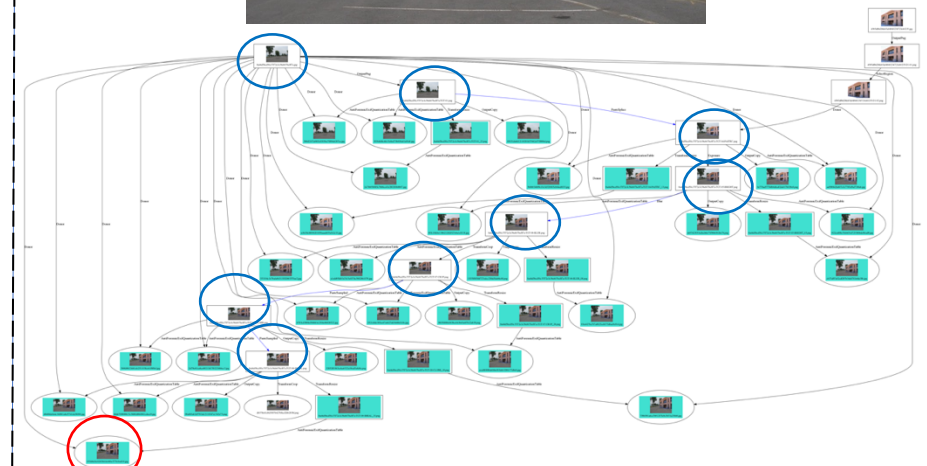
# MediFor Data History



**Kick-off  
2016 Dataset**



**Auto Journaling Tool (JT)  
Nimble Challenge 2017**

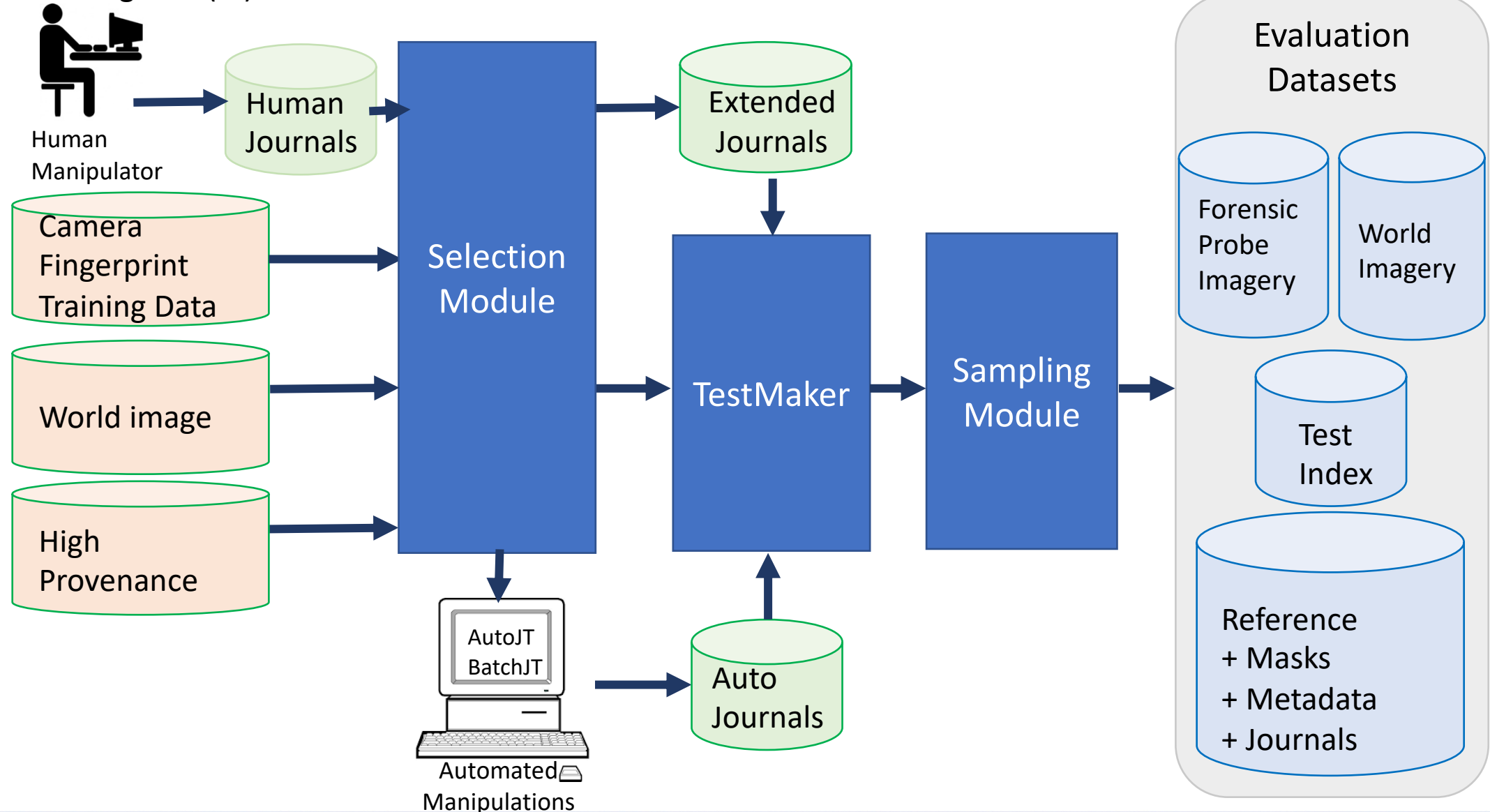


**MediaForensic Challenge 2018**

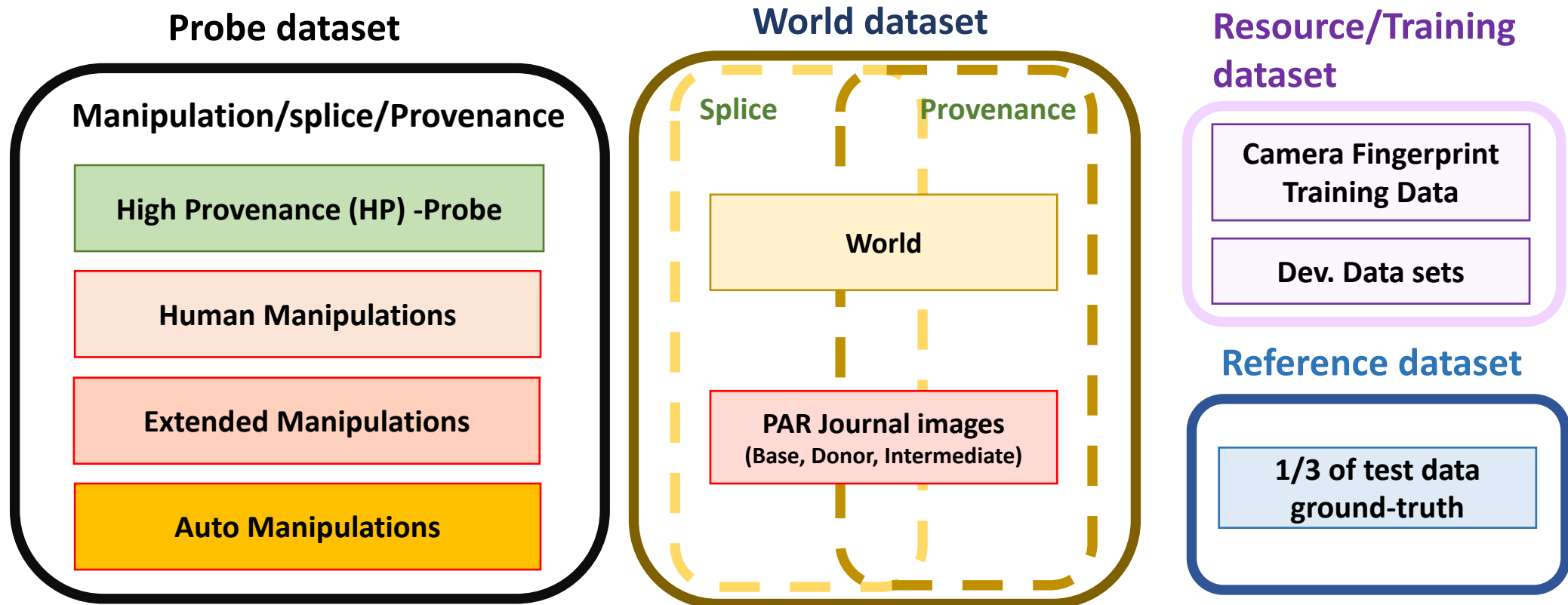


# Evaluation Dataset Production Infrastructure

Journaling Tool (JT)



# MFC18 General Datasets Overview (Image and Video)



# NIST Image Data Set Summary

- Each dataset contains the HP (high provenance) image, world image, manipulation journals etc.

NIST Data Sets	Image Probe (K)	Image Journal	Release Date	Information
Kick Off	1.1	400	07/2016	
NC17 Dev	3.5	≈ 400	04/2017	NC17 Auto
NC17 Eval	10	-	04/2017	NC17 Auto
NC17 Eval Part 1	4	406	06/2017	NC17 Auto
MFC18 Dev1	5.6	178	12/2017	
MFC18 Dev2	38	432	01/2018	Added MFC18 Auto
<b>MFC18 Eval</b>	<b>50</b>	-	<b>03/2018</b>	<b>Down Select on Probes</b>
<b>MFC18 EvalPart1</b>	<b>17</b>	<b>758</b>	<b>03/2018</b>	<b>Down Select on Probes</b>

# NIST Video Data Set Summary

NIST Data Sets	Video Journal	Video Probe	Release Date
NC17 Dev	≈23	214	04/2017
NC17 Eval	-	≈ 1K	04/2017
NC17 Eval Part 1	47	360	06/2017
MFC18 Dev1	8	118	12/2017
MFC18 Dev2	36	27	01/2018
<b>MFC18 Eval</b>	-	<b>3K</b>	<b>03/2018</b>
<b>MFC18 EvalPart1</b>	-	<b>1K</b>	<b>03/2018</b>



# NIST Provenance Data Set Summary

NIST Data Sets	Image Probe	Image Journal	World	Released Date
Kick Off	-	400	880	07/2016
NC17 Dev	3.5K	≈ 400	≈ 115K	04/2017
NC17 Eval	3K	-	1M	04/2017
NC17 Eval Part 1	1K	406	(1M)	06/2017
MFC18 Dev1	1.1K	178	10K	12/2017
MFC18 Dev2	1.2K	432	10K	01/2018
<b>MFC18 Eval</b>	<b>27K</b>	-	<b>5M</b>	<b>03/2018</b>
<b>MFC18 EvalPart1</b>	<b>10K</b>	-	<b>1M</b>	<b>03/2018</b>

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- ✓ MediFor Data Sets
- NIST Evaluation Software: MediScore
  - NIST Evaluation Scoring Server

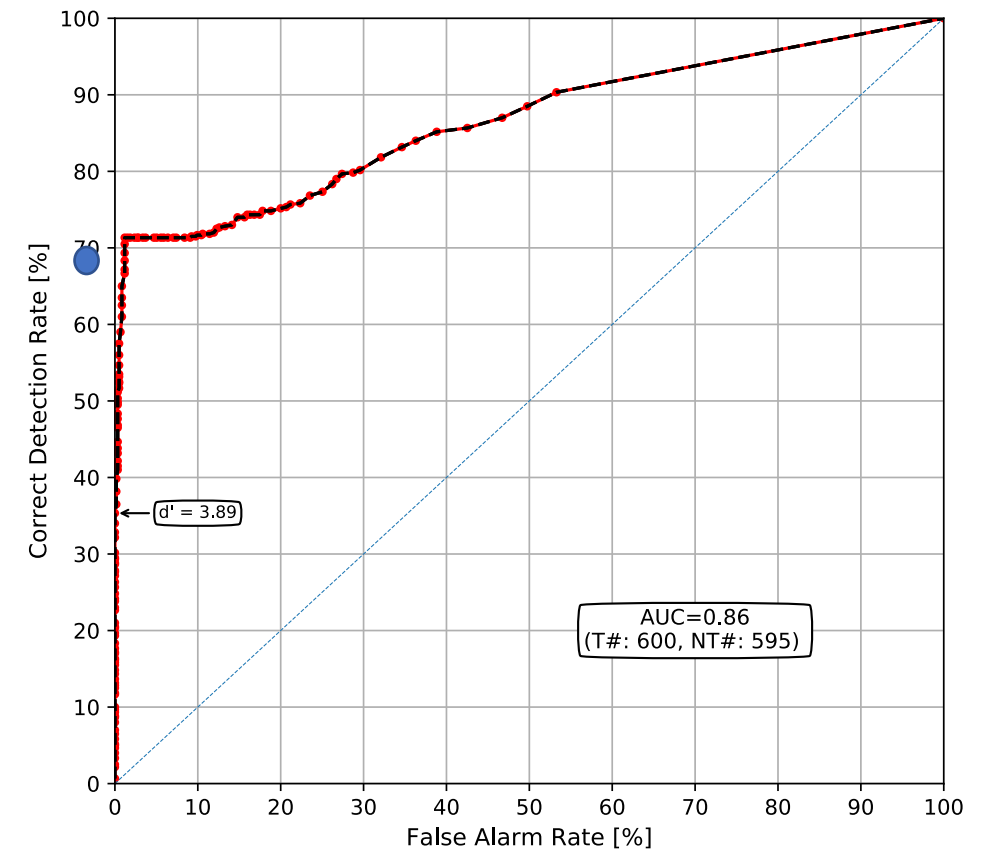
# Detection Scorer

- Manipulation (image/video), Splice, Event Verification, Camera tasks

- Metrics

- Area under (ROC) curve (AUC)
  - T# Number of Targets
  - NT# Number of Non-targets
- (New) CD (Correct detection)
  - @ False Alarm Rate (FAR) = 0.05
  - The TPR (True Positive Rate) value at FAR = 0.05

Performance



# Image Localization (Mask) Scorer

- Applied to Manipulation, Splice, and Camera fingerprint tasks
- Metrics
  - Matthews Correlation Coefficient (MCC)

$$MCC = \frac{TP \times TN - FP \times FN}{\sqrt{(TP + FP) \cdot (TP + FN) \cdot (TN + FP) \cdot (TN + FN)}} \in [-1, 1]$$

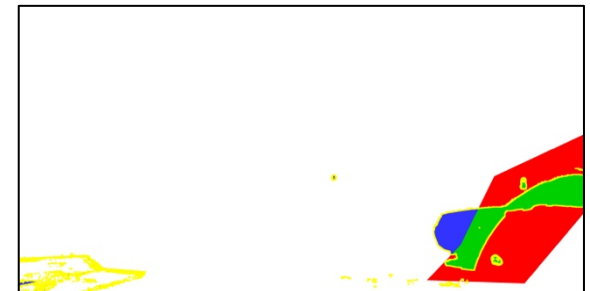
- 1 denotes perfect accuracy
  - 0 denotes no correlation between reference and system masks
  - -1 denotes perfect inaccuracy.
- Only evaluates on true targets



Probe + ref.  
mask overlay



System  
output mask



Color-coded  
scoring  
confusion  
matrix



# Localization Scorer – Selective Scoring

- JPEG2000 allows the localization scorer to evaluate for manipulations at any layer of the pixel



Sequence	Operation	Purpose	Color	Evaluated
5	ContentAwareFill	remove	Green	Y
4	PasteSampled	heal	Cyan	Y
3	PasteSplice	add	Orange	Y
2	Blur		Magenta	Y



# Selective Scoring – Table of Operations (MFC18)

Selective Scoring Name	ForImage	ForVideo	ForDetection	ForLocalization	ForProvFilt	ForProvGB	FilterCommand
PasteSplice	Y	N	Y	Y	N	N	-qm "Operation==['PasteSplice']"
ContentAwareRemove	Y	N	Y	Y	N	N	-qm "Operation==['ContentAwareFill']"
Clone	Y	N	Y	Y	N	N	-qm "Operation==['PasteSampled'] and Purpose==['clone']"
FaceManipulation	Y	N	Y	Y	N	N	-qm "OperationArgument==['face']"
Paste	Y	N	Y	Y	N	N	-qm "Operation == ['PasteSampled','PasteSplice']"
PasteSampled	Y	N	Y	Y	N	N	-qm "Operation==['PasteSampled']"
Remove	Y	N	Y	Y	N	N	-qm "Operation==['PasteSampled','ContentAwareFill'] and Purpose==['remove']"
Crop	Y	N	Y	N	N	N	-qm "Operation==['TransformCrop']"
LocalSharpening	Y	N	Y	Y	N	N	-qm "Operation==['Sharpening'] and Color!=""
GlobalIntensityNormalization	Y	N	Y	N	N	N	-qm "Operation==['Normalization']"

# (NEW) Video Temporal Localization Task

- Evaluation metrics: MCC

$$MCC = \frac{TP \times TN - FP \times FN}{\sqrt{(TP + FP) \cdot (TP + FN) \cdot (TN + FP) \cdot (TN + FN)}} \in [-1, 1]$$

- 1 denotes perfect accuracy, 0 denotes no correlation between reference and system masks, -1 denotes perfect inaccuracy.

- System validation check

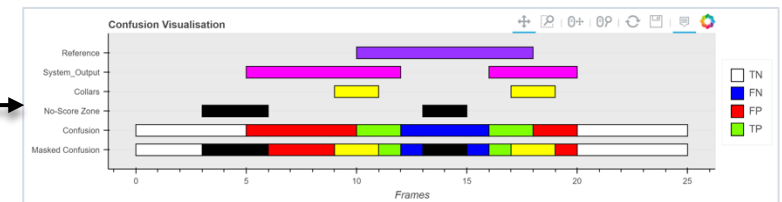
- Valid Video Segment and Audio Segments lists: '[' or '[[x<sub>1</sub>, x<sub>2</sub>], [x<sub>3</sub>, x<sub>4</sub>], ... ]'
- New --truncate option, to address inconsistent frameCounts issue.

- Score Output

*Sortable HTML dynamic table*

ProbeFileID	MCC	Timeline
ige7ybdq4yrqj69qg6pgjv7mdo6cjzw5	0.973861	<a href="#">plotLink</a>
shlc7l5lphshgowowpivxf3kyt711r4m	0.350365	<a href="#">plotLink</a>
1eced91laul47l6m6tu8w09xumigm2f6	0.100844	<a href="#">plotLink</a>
i69mzz5teh7kw3213qbh7ag899mlt44h	-0.579296	<a href="#">plotLink</a>
tg855d8hpdxyvht6ahwxuuxd3ilzqhdh	-0.455209	<a href="#">plotLink</a>
cub3x7recd5o8bpbpe3zjcthxuy5ruik	-0.371158	<a href="#">plotLink</a>

*Interactive Timeline Visualisation*



# Provenance Graph Filtering Task

- Evaluation metric definition

$$recall = \frac{|\{relevant\} \cap \{retrieved\}|}{|\{relevant\}|}$$

- Metric description
  - The recall of the first N images from the world dataset ( $\approx 1M$ ) sorted by 'confidence score'
  - Only true manipulated probes whose contributors are in the world data set are evaluated.
  - Different value for the depth of retrieval : recall@100, 200, 300.
- Node filtering option
  - Compute each recall for each Node Type.



# Provenance Graph Building Task

- Evaluation metrics: Graph Similarity and Generalized F-measure

- Nodes overlap:  $\text{sim}_{\text{NO}}(G_r, G_s) = 2 \frac{|V_r \cap V_s|}{|V_r| + |V_s|}$

- Links overlap:  $\text{sim}_{\text{LO}}(G_r, G_s) = 2 \frac{|E_r \cap E_s|}{|E_r| + |E_s|}$

- Nodes and links overlap:  $\text{sim}_{\text{NLO}}(G_r, G_s) = 2 \frac{|V_r \cap V_s| + |E_r \cap E_s|}{|V_r| + |V_s| + |E_r| + |E_s|}$

- Two graph scoring options:

- Direct Path Limited : All direct ancestor and descendants of a given probe
- Full Graph : Recursively include all paths connected to the probe and all ancestors and descendants



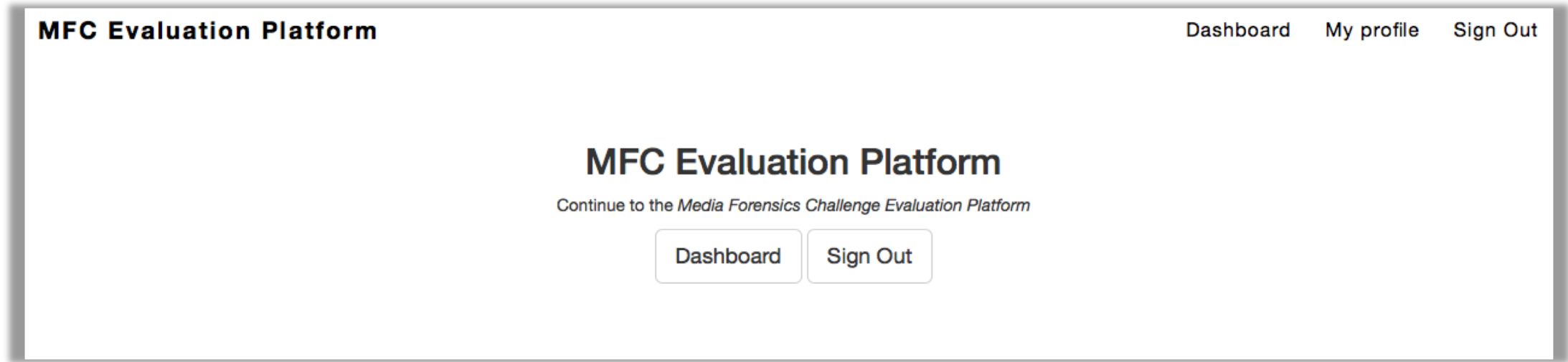
## Graph legend

	Green	Red	Gray
Image border	Correctly included	False alarm image	Omitted provenance image (missed detection)
Link	Correctly linked images	False alarm link	Omitted link

# Outline

- ✓ MediFor Evaluation Tasks
- ✓ NIST Data Sets
- ✓ NIST Evaluation Software: MediScore
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# Scoring Server



## Updates

## Future

- Two new evaluation tasks
  - Camera Fingerprint ID
  - Event Verification
- Backend database for analysis
  - System output
  - Scoring results
- Storage Management
  - Balance hard drive usage (~20 TB so far)
- Selective Scorings
  - Updates to selective scorings for MFC18 Data
    - GlobalIntensityNormalization
    - LocalSharpening
    - ContentAwareRemove
    - LocalAdditionalEffectBlur
  - CopyPaste – Video Detection
  - Localization only scores on localizable selective scorings
- Analysis Pipeline
- Scoring server refresh

# Disclaimer

- All images, graphs, and charts are original works created under contract on the DARPA MediFor Program
- Certain commercial equipment, instruments, software, or materials are identified in this article in order to specify the experimental procedure adequately. Such identification is not intended to imply recommendation or endorsement by NIST, nor is it intended to imply that the equipment, instruments, software or materials are necessarily the best available for the purpose.
- The views, opinions and/or findings expressed are those of the author and should not be interpreted as representing the official views or policies of the Department of Defense or the U.S. Government.

# Thank You for Your Attention!

- **NIST Medifor Team:** [mfc\\_poc@nist.gov](mailto:mfc_poc@nist.gov)
- **MediScore Github:** <https://github.com/usnistgov/MediScore>
- **NIST Medifor Evaluation (2017 and 2018):**  
<https://www.nist.gov/itl/iad/mig/nimble-challenge-2017-evaluation>  
<https://www.nist.gov/itl/iad/mig/media-forensics-challenge-2018>