



# The 1<sup>st</sup> Large-Scale Kinship Recognition Database: To visually recognize and understand families in the wild

Joseph P. Robinson<sup>1</sup> and Yun Fu<sup>1,2</sup>

<sup>1</sup>Department of Electrical and Computer Engineering, Northeastern University, USA

<sup>2</sup>College of Computer and Information Science, Northeastern University, USA



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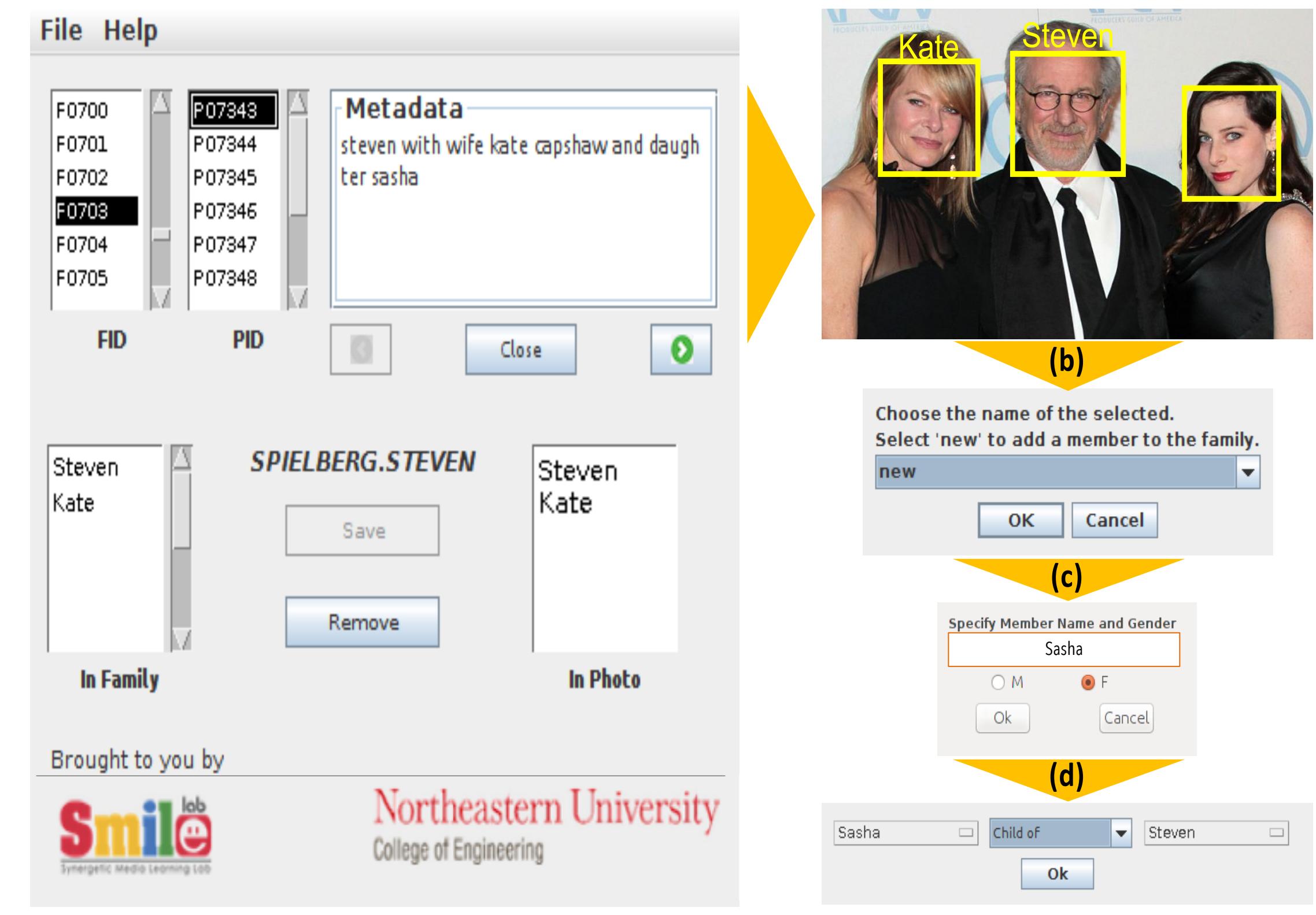
## Motivation

- Automatic kinship recognition is a challenging task.
- After lots of focus since 2010, it has yet to transition from research-to-reality:
  - Existing datasets do not properly represent true data distributions.
  - Complex factors of the problem remain unfound throughout ML community.

**Goal:** Build large-scale kinship dataset to best support the task of kinship recognition.

## Families In The Wild

- Built the largest image dataset for kinship recognition to date [1].
- Collected and annotated over 31,000 facial images (**Table 2**)
- Provided 365k pairs, 11 types, with 4 grandparents-children for 1<sup>st</sup> time (**Table 1**)
- Developed annotation tool to capture complex family structures (**Fig 1**)



**Fig 1** Labeling tool used to build FIW v1.0 (a). Faces are detected and bounded by resizable boxes (b). Existing member names are specified via dropdown menu—if new is selected (c), then name and gender is specified (d), along with relationships to others (e).

## Semi-Automatic Annotation

- While initial annotation process worked, it was slower than ideal and prone to human error.
- When finalizing FIW, we optimized this process by proposing labels using k-means clustering with true labels as side information, where our objective function can be expressed in **Eq 1**.

$$\min \sum_{k=1}^K \sum_{x_i \in C_k} f_{\cos}(x_i, m_k) + \lambda U_c(S, H \otimes S), \quad (1)$$

where  $f_{\cos}$  is cosine similarity,  $H$  is final partition,  $H_s = H \otimes S$  is partition of  $H$  with instances as side information  $S$ ,  $m_k$  is centroid of  $C_k$ ,  $U_c$  is Categorical Utility Function, and  $\lambda$  is trade-off parameter. The first term is the standard K-means with cosine similarity, and the second term can also be transformed into a K-means problem with squared Euclidean distance.

A cluster validation tool was developed in JAVA, i.e., cluster id-> true lable (**Fig 2**).



**Table 1** No. pairs in FIW and other kinship image collections.

Pair-Type	KFW-II [7]	Sibling Face [14]	Group Face [15]	Family 101 [8]	FIW v1.0 (Ours) [2]	FIW v2.0 (Ours) [1]
Brother-Brother	--	232	40	--	<b>86,000</b>	<b>130,000</b>
Sister-Sister	--	211	32	--	<b>86,000</b>	<b>130,000</b>
Siblings	--	277	53	--	<b>75,000</b>	<b>105,000</b>
Father-Daughter	250	--	69	147	<b>45,000</b>	<b>75,000</b>
Father-Son	250	--	69	213	<b>43,000</b>	<b>75,000</b>
Mother-Daughter	250	--	62	148	<b>44,000</b>	<b>64,000</b>
Mother-Son	250	--	70	184	<b>37,000</b>	<b>60,000</b>
GF-GD	--	--	--	--	<b>410</b>	<b>1,000</b>
GF-GS	--	--	--	--	<b>350</b>	<b>2,350</b>
GM-GD	--	--	--	--	<b>550</b>	<b>950</b>
GM-GS	--	--	--	--	<b>750</b>	<b>2,000</b>
Total	1,000	720	395	607	<b>418,060</b>	<b>645,000</b>

**Table 2** Comparison of FIW with related datasets.

Dataset	No. Fam.	No. People	No. Faces	Age Varies	Full Fam.	Highlights
CornellKin [6]	150	300	300	No	No	Parent-child pairs.
UB KinFace-I [9]	90	180	270	Yes	No	Parent-child pairs. Parents' 139 images at various ages.
UB KinFace-II [9]	200	400	600	Yes	No	Parent-child pairs. Parents' 139 images at various ages.
KFW-I [7]	--	1,066	1k	No	No	Parent-child pairs.
KFW-II [7]	--	2,000	2k	No	No	Parent-child pairs.
TSKinFace [10]	787	2,589	--	Yes	Yes	2 parents-child pairs, tri-verification.
Family101 [8]	101	607	14k	Yes	Yes	Family structured, variations in age and ethnicity.
<b>FIW(Ours) [1]</b>	<b>1,000</b>	<b>10,700</b>	<b>31,000</b>	Yes	Yes	Provides both depth & breadth and multi-task evaluation offerings.

## Experiments

### Kinship Verification on FIW.

- Kin relation types and sample sizes (**Table 1** & **Fig 3**).
- Cross-validated on 5-fold (**Table 4**).
- Both fine-tuned VGG-Face and Centerface deep CNN models achieved top scores.

### Family Classification.

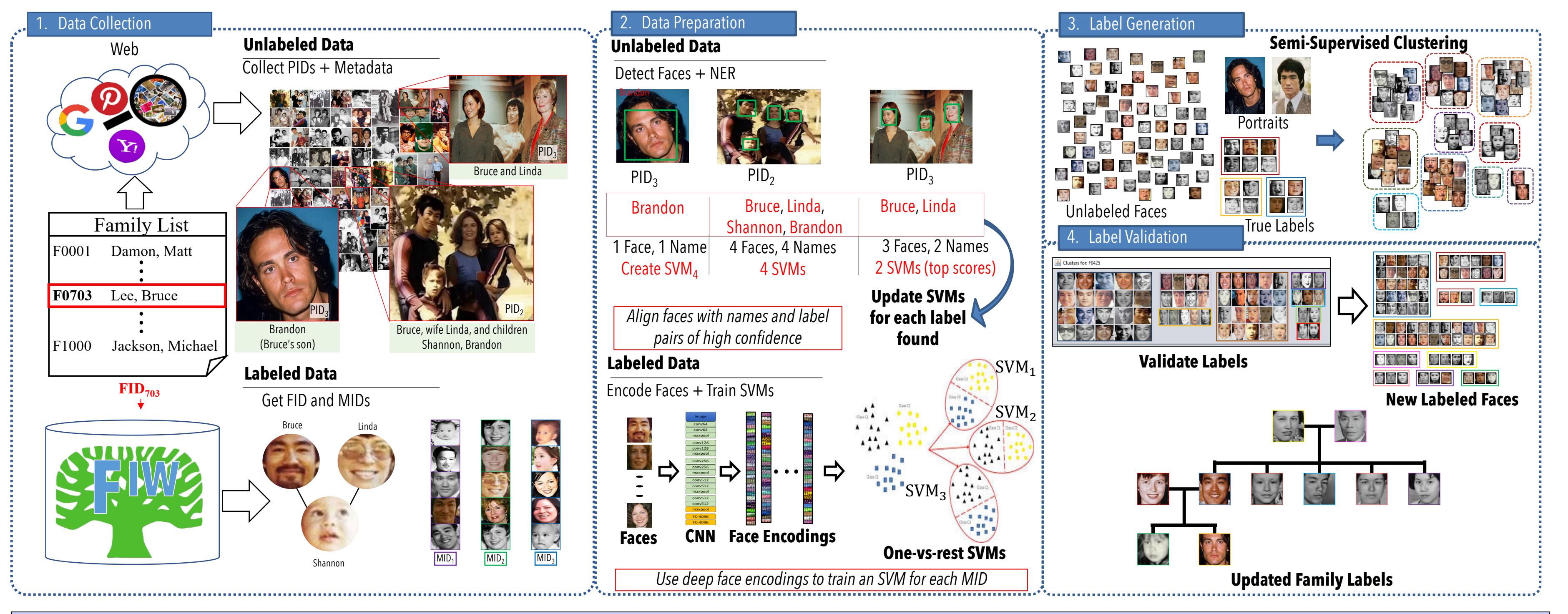
- VGG-Face + one-vs-rest SVMs were used as baseline.
- Five members from families which have more than five members were randomly selected, resulting in 524 families with total 12,007 images.
- Fine-tuned Centerface model achieved top score of 11.34% (**Table 3**).

### Human Kinship Verification.

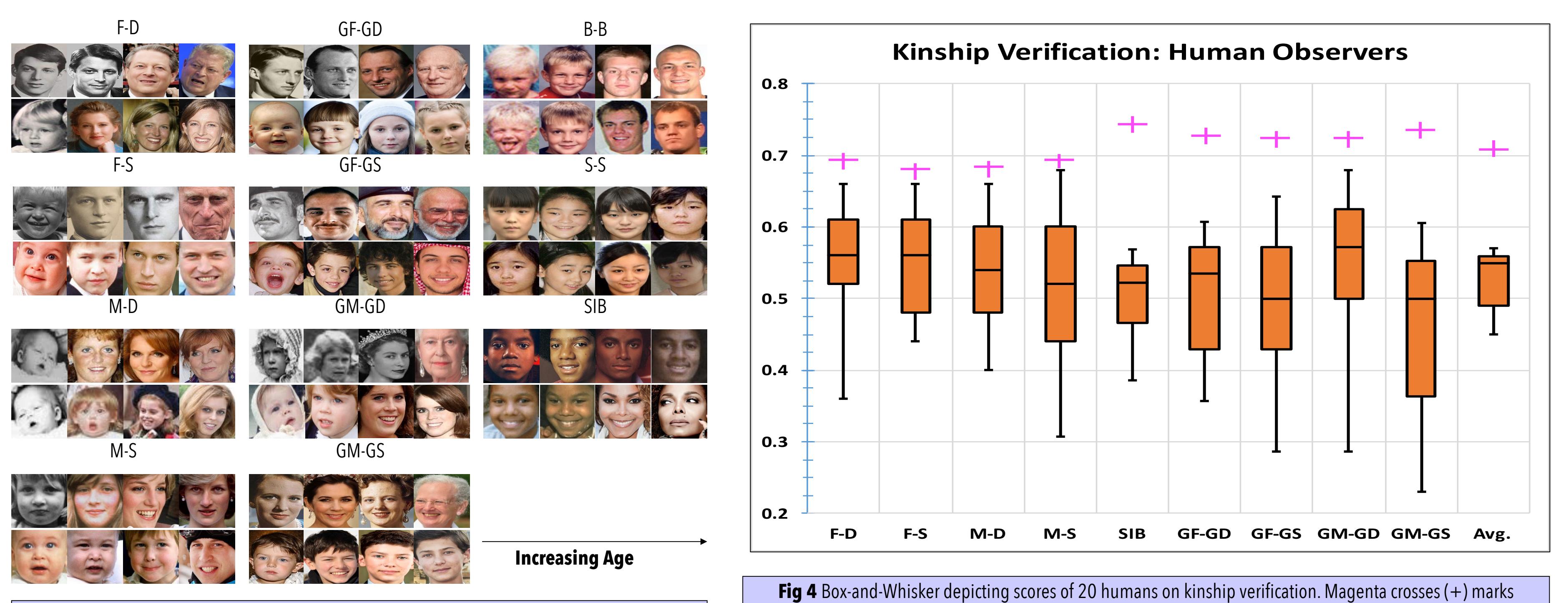
- Human performers scored an overall average of 56.6%, which was outscored by fine-tuned CNN by approximately 15% (**Fig 4**), using 200 pairs of the 11 types.

### Semi-Automatic Annotation

- Semi-supervised clustering algorithm reduced time to annotate a family by 52% and clicks to annotate a family by 68% (**Fig 3**), in comparison to initial annotation process (**Fig 1**).



**Fig 2** Semi-automatic labeling pipeline: Photos and metadata collected for underrepresented families (**Data Collection**). Existing labels, portrait photos, and metadata used as side information to facilitate clustering (**Data Preparation**). Then, label proposals generated via semi-supervised model (**Label Generation**). JAVA tool used to validate labels (**Label Validation**).



**Fig 3** Sample pairs for the 11 kinship relations provided by the FIW database.

**Table 3** Family classification scores on 524 families.

Network(s) Details	Acc.
VGG-f <sub>c</sub> +one-vs-all SVMs 4096D	2.87
VGG fine-tuned softmax 524D	10.48
Centerface + SVM	2.15
Centerface (CF)	<b>11.34</b>
FT CF	<b>70.1</b> <b>71.5</b> <b>72.0</b> <b>71.2</b> <b>72.8</b> <b>77.4</b> <b>77.0</b> <b>66.9</b> <b>69.4</b> <b>67.8</b> <b>68.6</b> <b>71.3</b>
FT + Triplet loss + PCA	68.1 70.1 69.0 68.5 <b>77.2</b> <b>78.3</b> 75.6 <b>78.1</b> <b>77.1</b> <b>78.0</b> <b>74.8</b> <b>74.1</b>

**Table 4** Verification scores. No family overlap between (5) folds. Top accuracies obtained by fine-tuned (FT) VGG-Face on FIW.

	F-D	F-S	M-D	M-S	SIBS	B-B	S-S	GF-D	GF-S	GM-D	GM-S	Avg.
LBP	54.8	54.7	55.8	55.3	57.2	57.7	56.4	56.4	56.4	54.3	56.9	55.7
SIFT	56.1	56.3	56.3	55.4	58.8	57.8	59.0	56.9	56.1	60.3	58.0	57.1
<b>VGG-Face</b>	64.6	64.6	66.0	63.7	73.2	70.1	71.0	60.8	63.1	59.9	61.9	64.1
<b>VGG-Face LMNN</b>	65.7	67.1	68.1	67.2	73.9	70.1	72.3	68.9	60.4	63.7	60.2	65.6
<b>Centerface (CF)</b>	57.6	58.8	58.7	58.0	68.6	70.3	68.9	71.1	74.7	77.2	70.4	66.8
<b>FT CF</b>	<b>70.1</b>	<b>71.5</b>	<b>72.0</b>	<b>71.2</b>	<b>72.8</b>	<b>77.4</b>	<b>77.0</b>	<b>66.9</b>	<b>69.4</b>	<b>67.8</b>	<b>68.6</b>	<b>71.3</b>
<b>FT + Triplet loss + PCA</b>	68.1	70.1	69.0	68.5	<b>77.2</b>	<b>78.3</b>	75.6	<b>78.1</b>	<b>77.1</b>	<b>78.0</b>	<b>74.8</b>	<b>74.1</b>

## Conclusions

- Built the largest and most comprehensive image database for kinship recognition to date, along with the labels, baseline results, and evaluation protocols needed to further and track future progress.
- Finalized database as FIW v2.0 using a semi-automatic labeling pipeline with a verification tool to add new data more efficiently, reducing annotation time and clicks per family by 52% and 68%, respectively, and increasing the number of pairs by ~227,000.
- Found pre-trained CNNs yield the best features for our unconstrained dataset.
- Revealed algorithms outperform humans doing the verification tasks.
- Obtained top scores for both kinship verification and family recognition by fine-tuning CNN network on FIW data.

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