



The 1st Large-Scale Kinship Recognition Database: To visually recognize and understand families in the wild

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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 1st time (**Table 1**)
- Developed annotation tool to capture complex family structures (**Fig 1**)

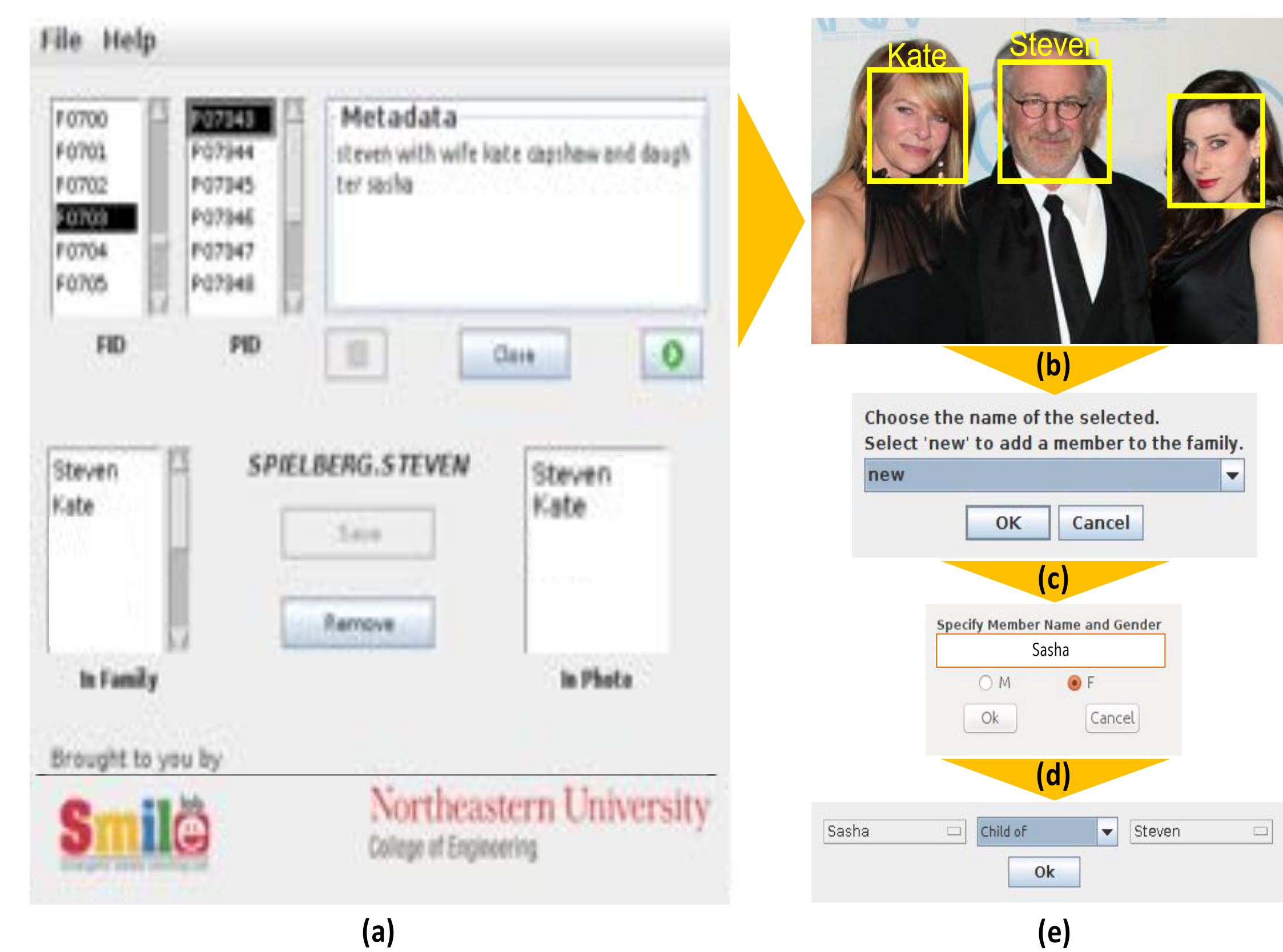


Fig 1 Labeling tool used to build FIW v1.0 (a). Faces are detected and bounded by resizable boxes (b). Existing member names are specified via dropdown menu- if *new* is selected (c), then name and gender is specified (d), along with relationships to others (e).

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 λ 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 Euclidian distance.

- A cluster validation tool was developed in JAVA, i.e., cluster id > true label (**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	--	86,000	130,000
Sister-Sister	--	211	32	--	86,000	130,000
Siblings	--	277	53	--	75,000	105,000
Father-Daughter	250	--	69	147	45,000	75,000
Father-Son	250	--	69	213	43,000	75,000
Mother-Daughter	250	--	62	148	44,000	64,000
Mother-Son	250	--	70	184	37,000	60,000
GF-GD	--	--	--	--	410	1,000
GF-GS	--	--	--	--	350	2,350
GM-GD	--	--	--	--	550	950
GM-GS	--	--	--	--	750	2,000
Total	1,000	720	395	607	418,060	645,000

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.
FIW(Ours) [1]	1,000	10,700	31,000	Yes	Yes	Provides both depth & breadth and multi-task evaluation offerings.

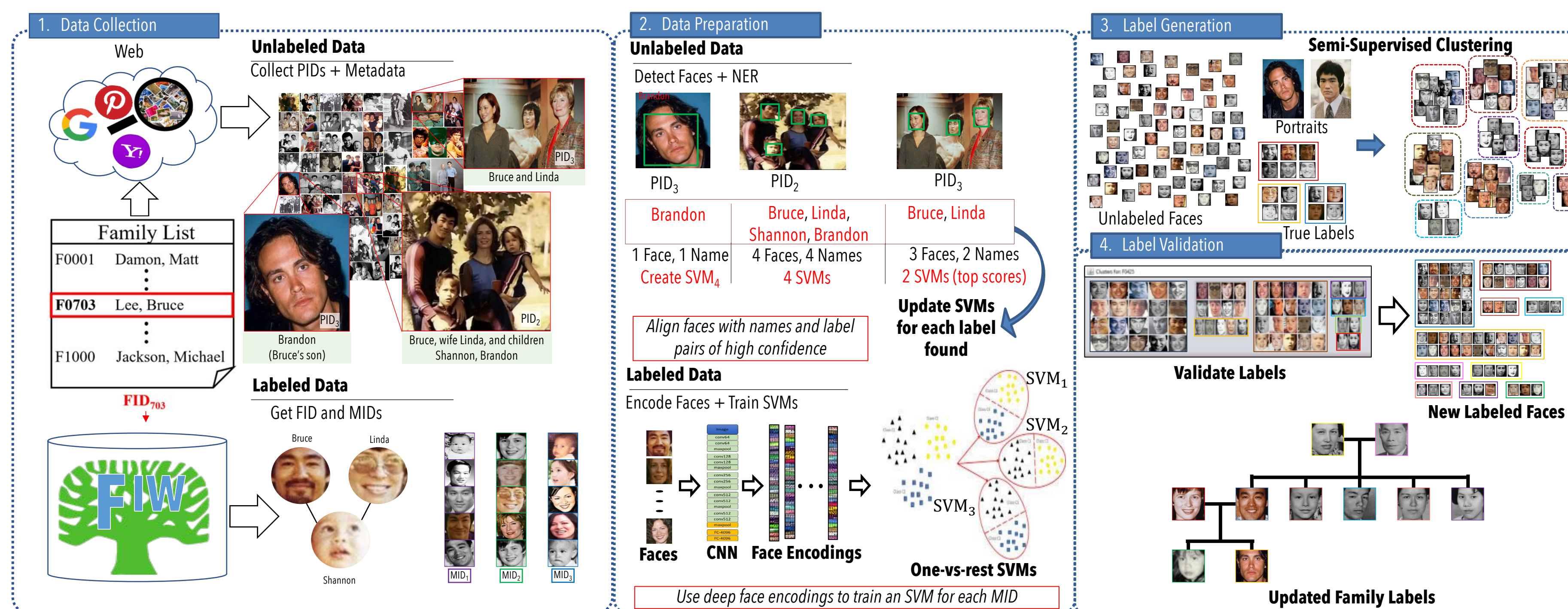


Fig 2 Semi-automatic labeling pipeline: Photos and metadata collected for underrepresented families (**Data Collection**). Existing labels, portrait photos, and metadata used as side information to facilitate clustering (**Data Preparation**). Then, label proposals generated via semi-supervised model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

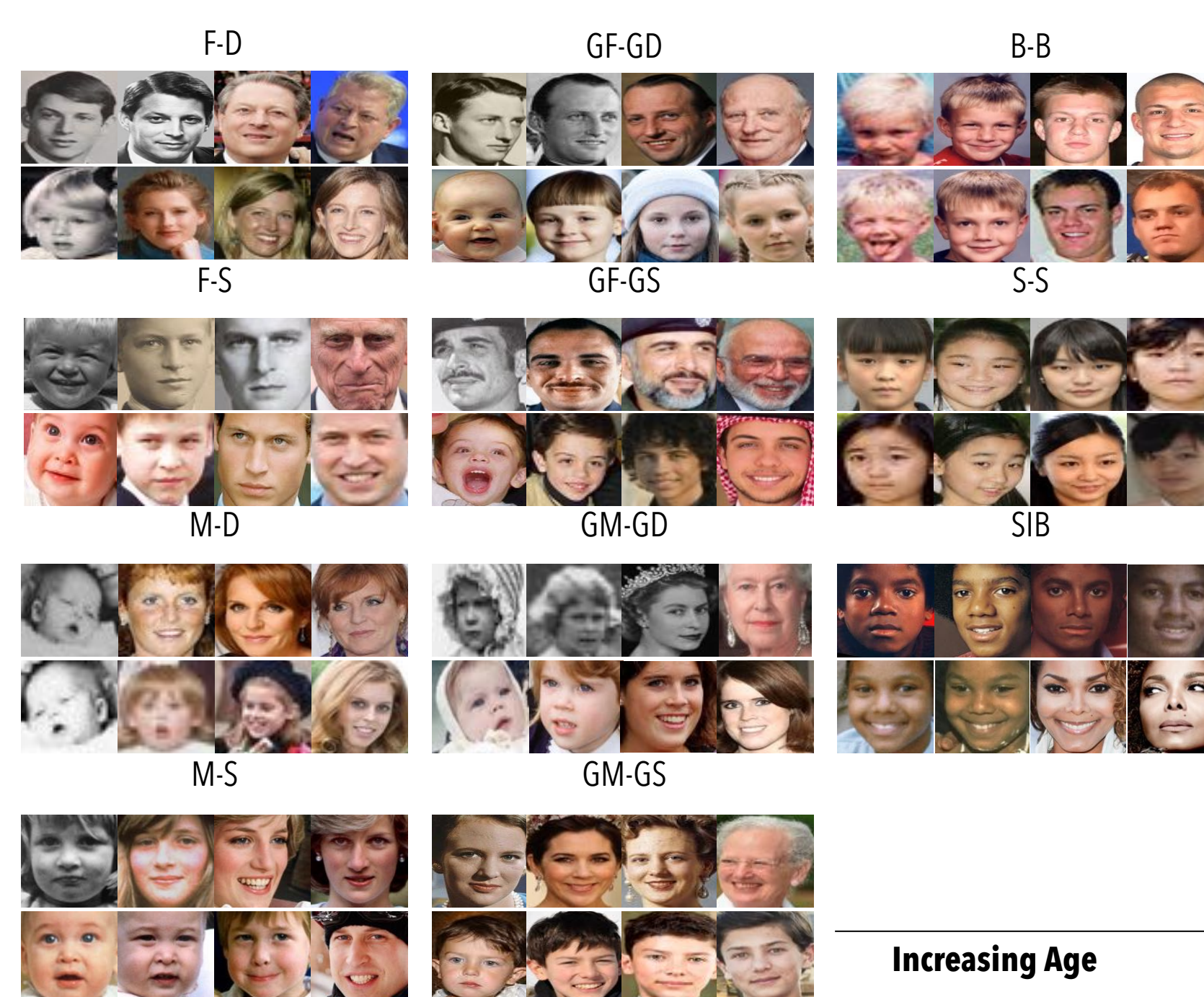


Fig 3 Sample pairs for the 11 kinship relations provided by the FIW database.

Table 3 Family classification scores on 524 families.

Network(s) Details	Acc.
VGG-f ₁₇ + one-vs-all SVMs 4096D	2.87
VGG fine-tuned softmax 524D	10.48
Centerface + SVM	2.15
Centerface fine-tuned	11.34

Table 4 Verification scores. No family overlap between (S) 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
VGG-Face	64.6	64.6	66.0	63.7	73.2	70.1	71.0	60.8	63.1	59.9	61.9	64.1
VGG-Face LMNN	65.7	67.1	68.1	67.2	73.9	70.1	72.3	63.9	60.4	63.7	60.2	65.6
Centerface (CF)	57.6	58.8	58.7	58.0	68.6	70.3	68.9	71.1	74.7	77.2	70.4	66.8
FT CF	70.1	71.5	72.0	71.2	72.8	77.4	77.0	66.9	69.4	67.8	68.6	71.3
FT + Triplet loss + PCA	68.1	70.1	69.0	68.5	77.2	78.3	75.6	78.1	77.1	78.0	74.8	74.1

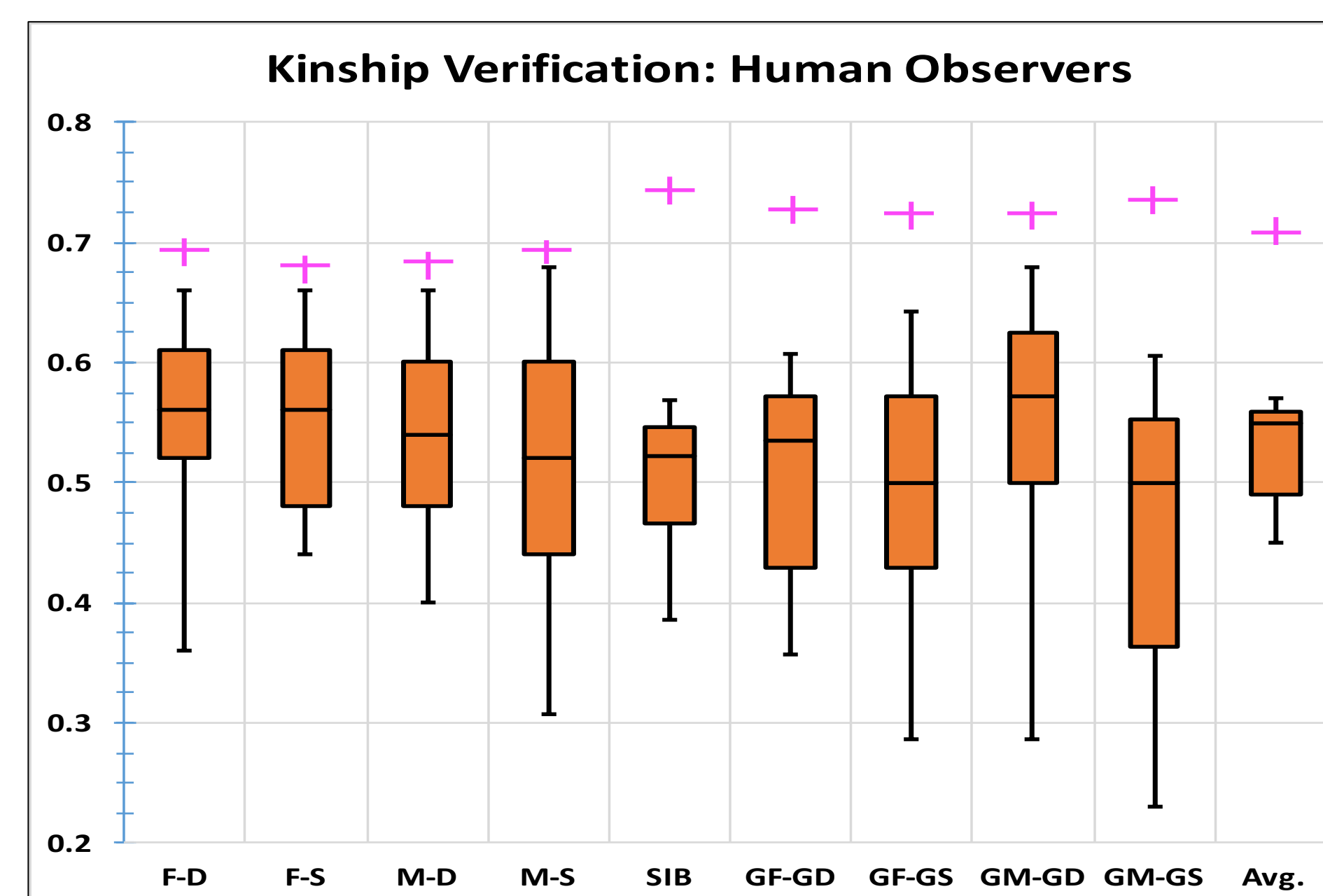


Fig 4 Box-and-Whisker depicting scores of 20 humans on kinship verification. Magenta crosses (+) marks average score of fine-tuned CNN model, which outperforms humans in every category.

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**).

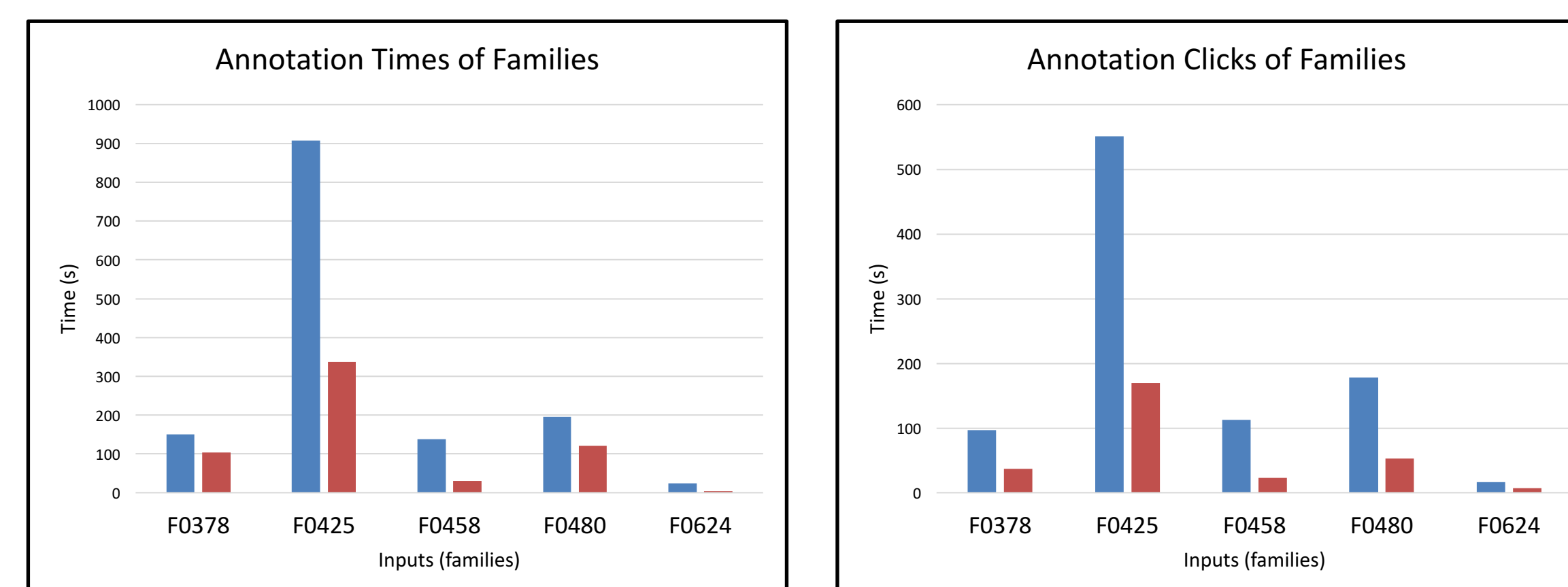


Fig 3 Comparison in time (left) and manual input (right) between old (blue) and new (red) labeling scheme.

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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