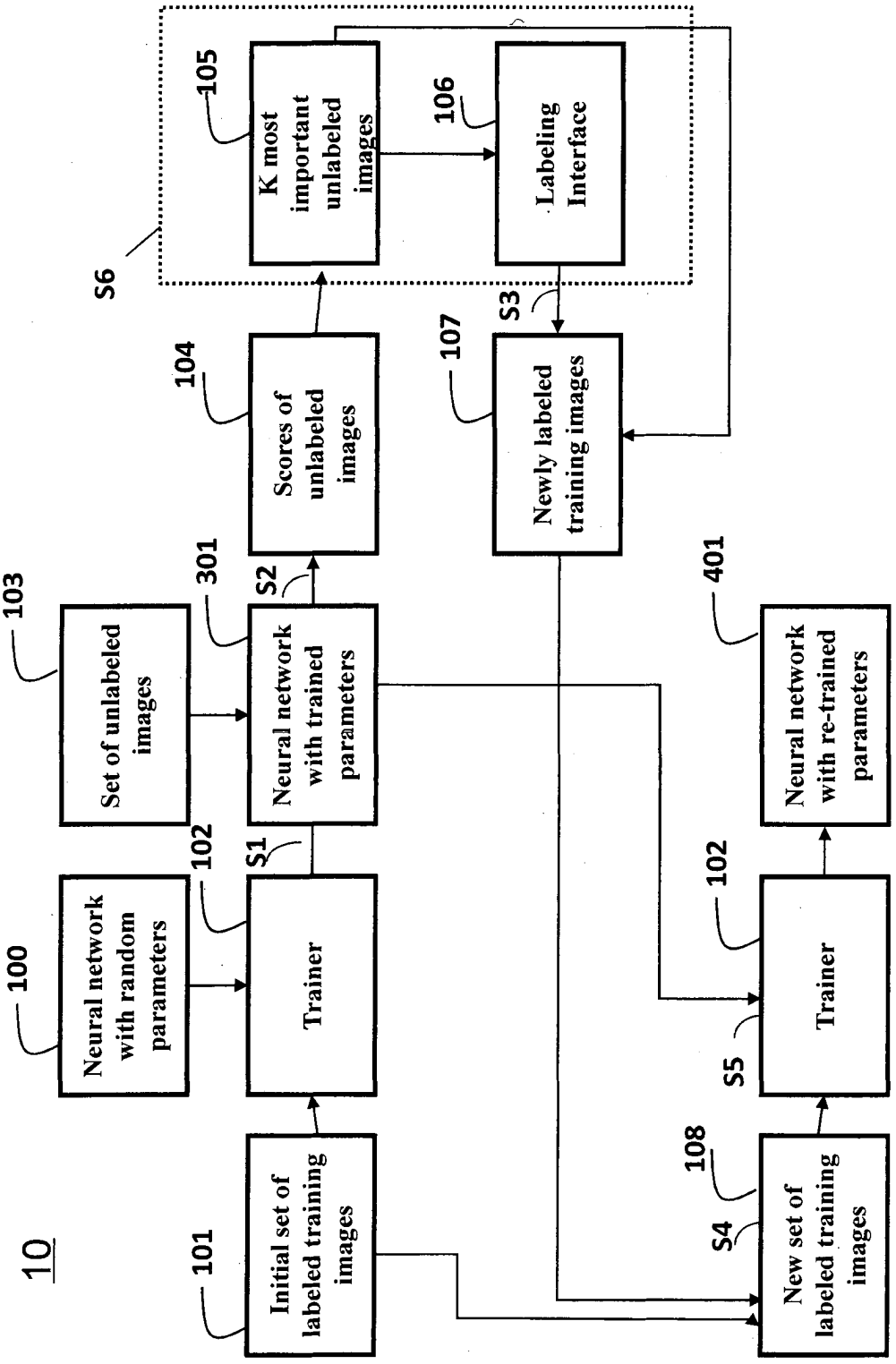
10
Initial set of labeled training images
101
Neural network with random parameters
100
Trainer
102
S1
Neural network with trained parameters
301
Set of unlabeled images
103
S2
Scores of unlabeled images
104
K most important unlabeled images
105
S6
Labeling Interface
106
S3
Newly labeled training images
107
New set of labeled training images
108
S4
Trainer
102
S5
Neural network with re-trained parameters
401

FIG. 1A

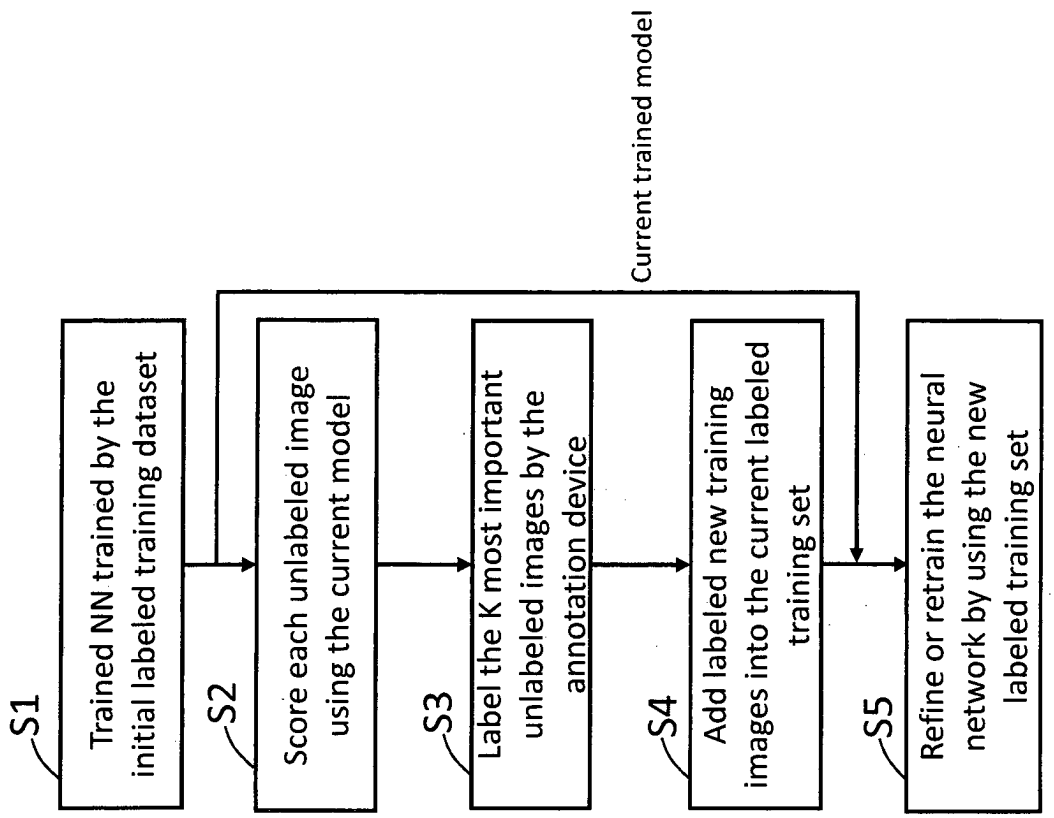
Current trained model
S1
Trained NN trained by the initial labeled training dataset
S2
Score each unlabeled image using the current model
S3
Label the K most important unlabeled images by the annotation device
S4
Add labeled new training images into the current labeled training set
S5
Refine or retrain the neural network by using the new labeled training set

FIG. 1B

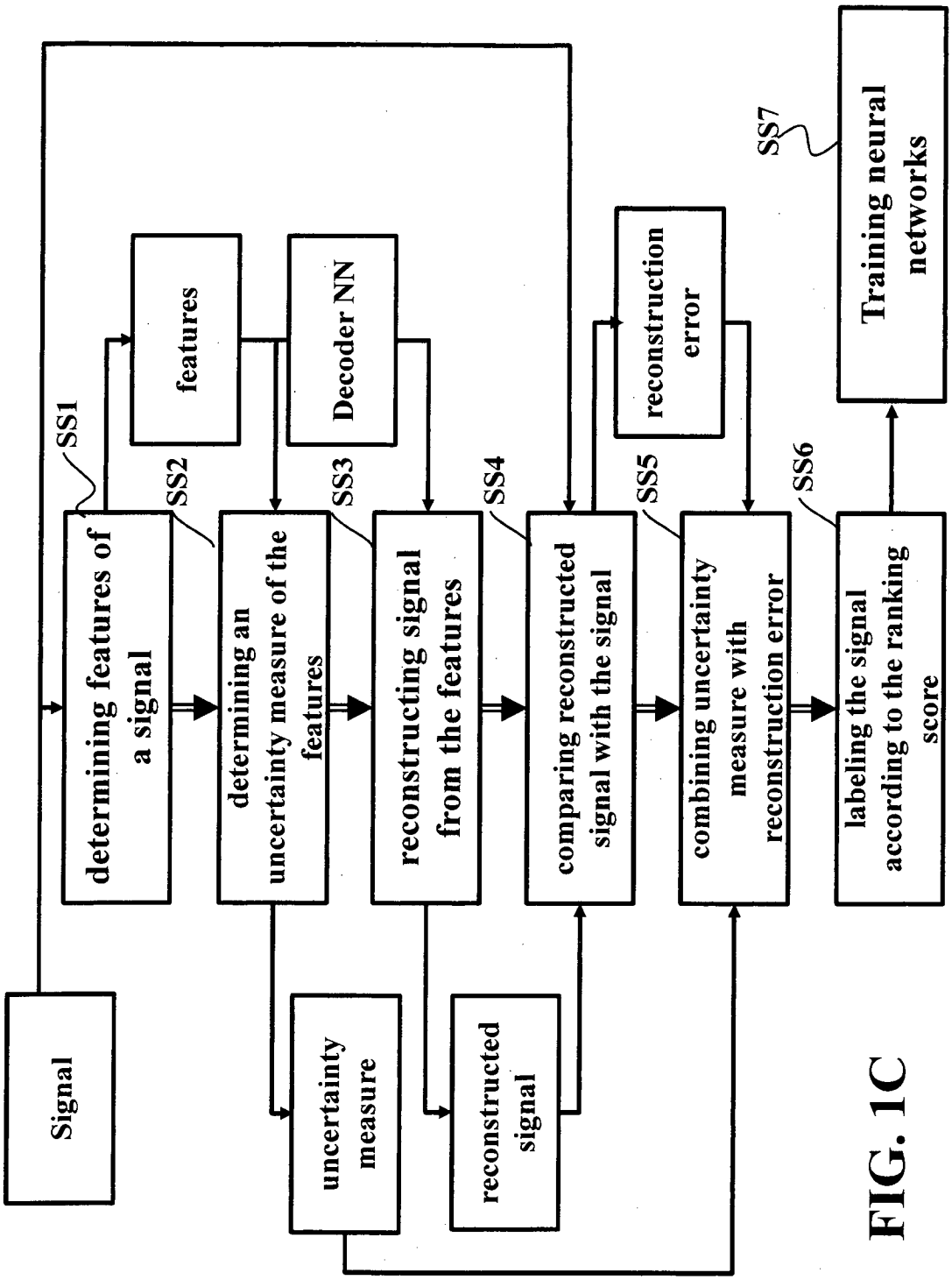
Signal
determining features of a signal
features
SS1
SS2
determining an uncertainty measure of the features
Decoder NN
SS3
reconstructing signal from the features
SS4
comparing reconstructed signal with the signal
reconstruction error
SS5
combining uncertainty measure with reconstruction error
SS6
labeling the signal according to the ranking score
SS7
Training neural networks
uncertainty measure
reconstructed signal

FIG. 1C

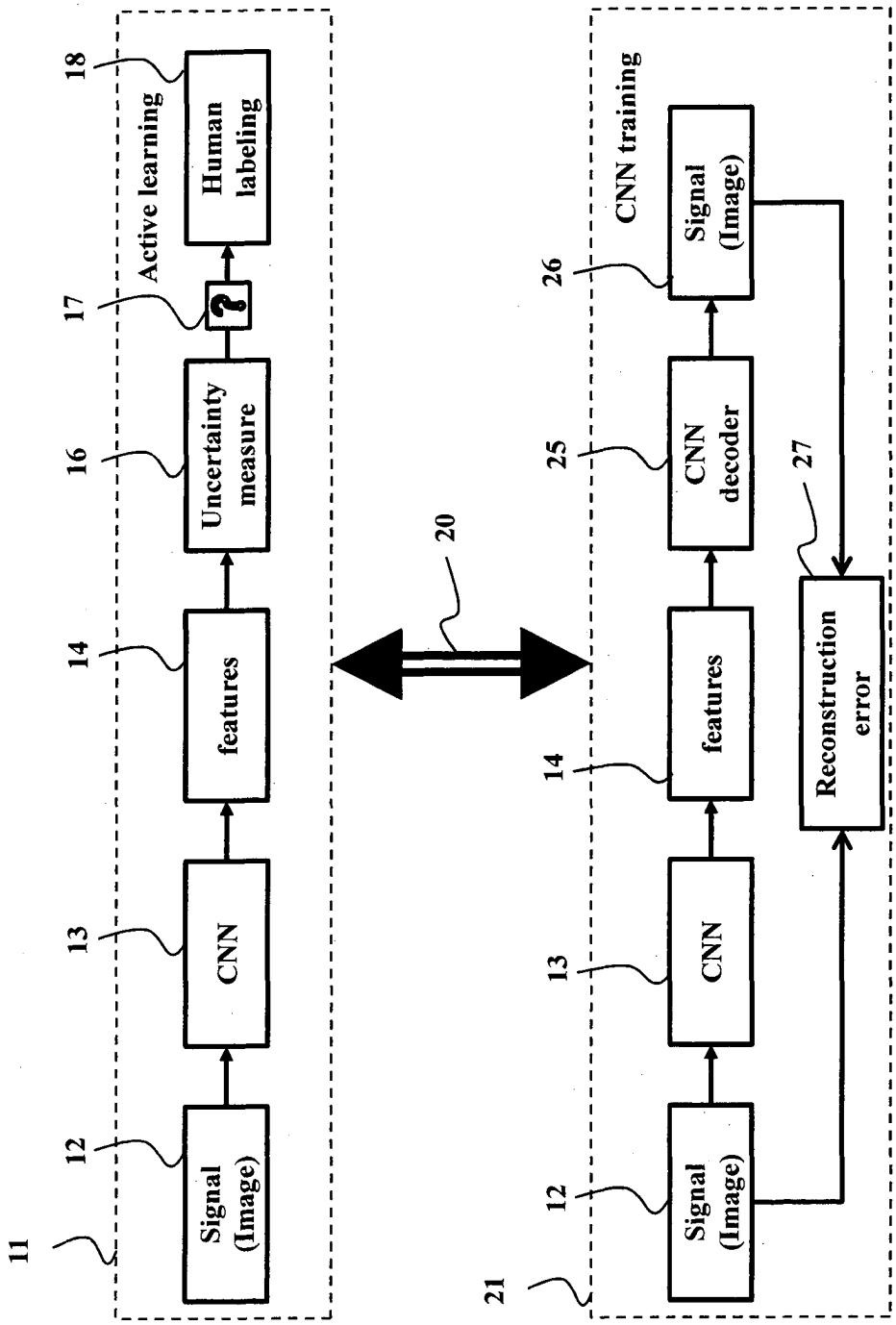
11
12
Signal (Image)
13
CNN
14
features
16
Uncertainty measure
17
Active learning
18
Human labeling
20
21
12
Signal (Image)
13
CNN
14
features
25
CNN decoder
26
Signal (Image)
CNN training
27
Reconstruction error

FIG. 1D

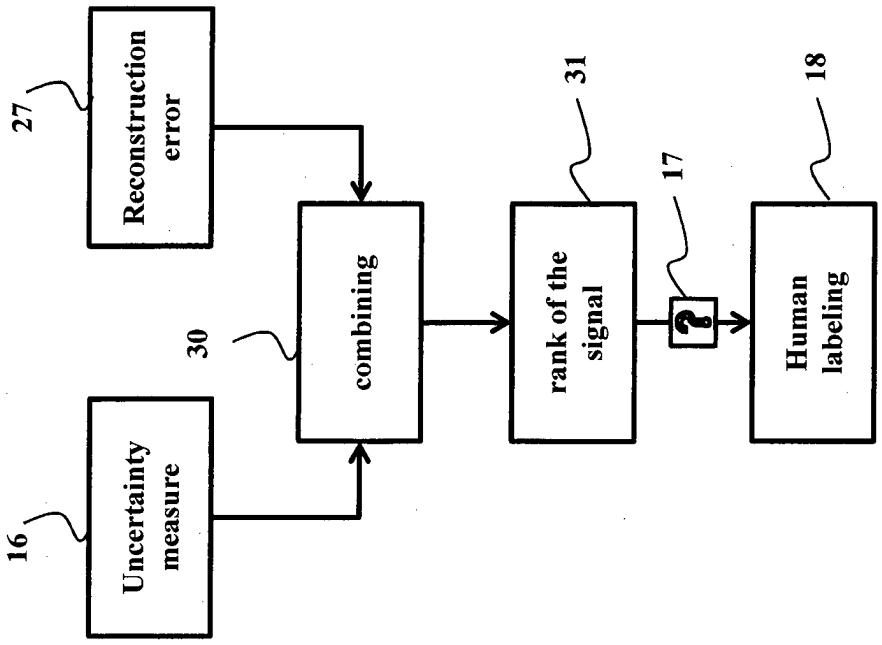
Reconstruction error
27
Uncertainty measure
16
30
combining
rank of the signal
31
17
?
Human labeling
18

FIG. 1E

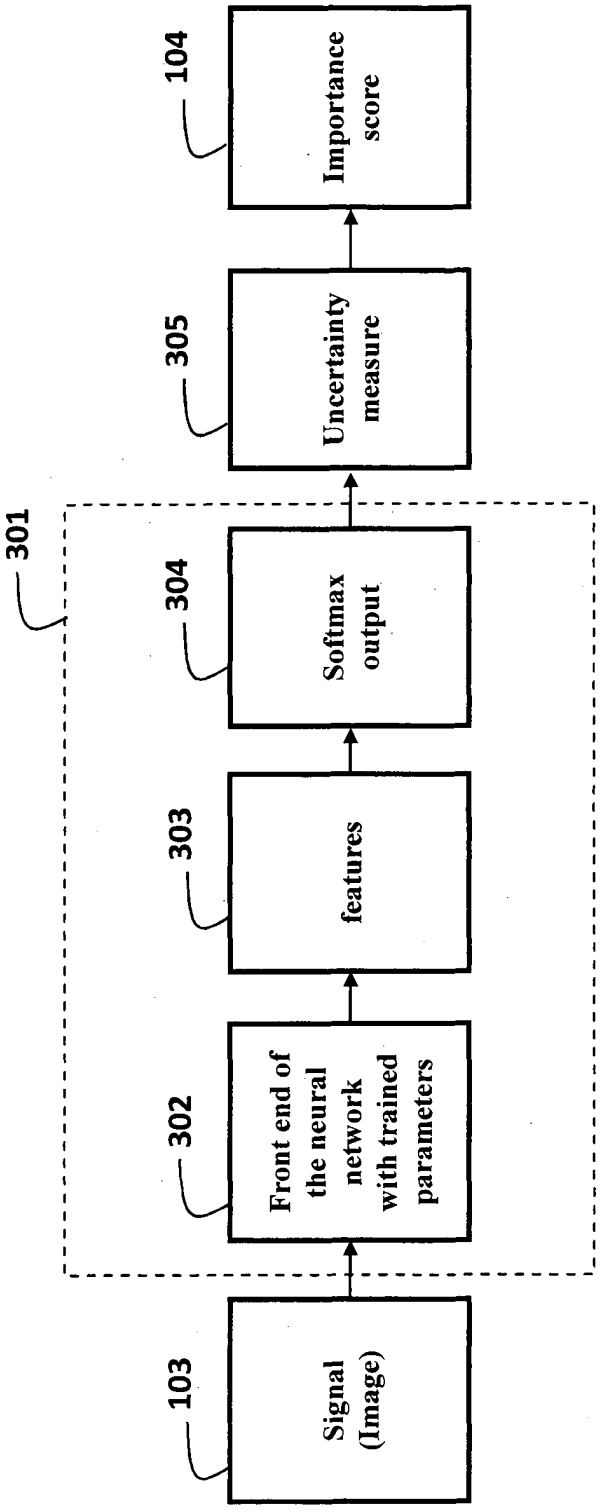
104
Importance score
305
Uncertainty measure
301
304
Softmax output
303
features
302
Front end of the neural network with trained parameters
103
Signal (Image)

FIG. 2

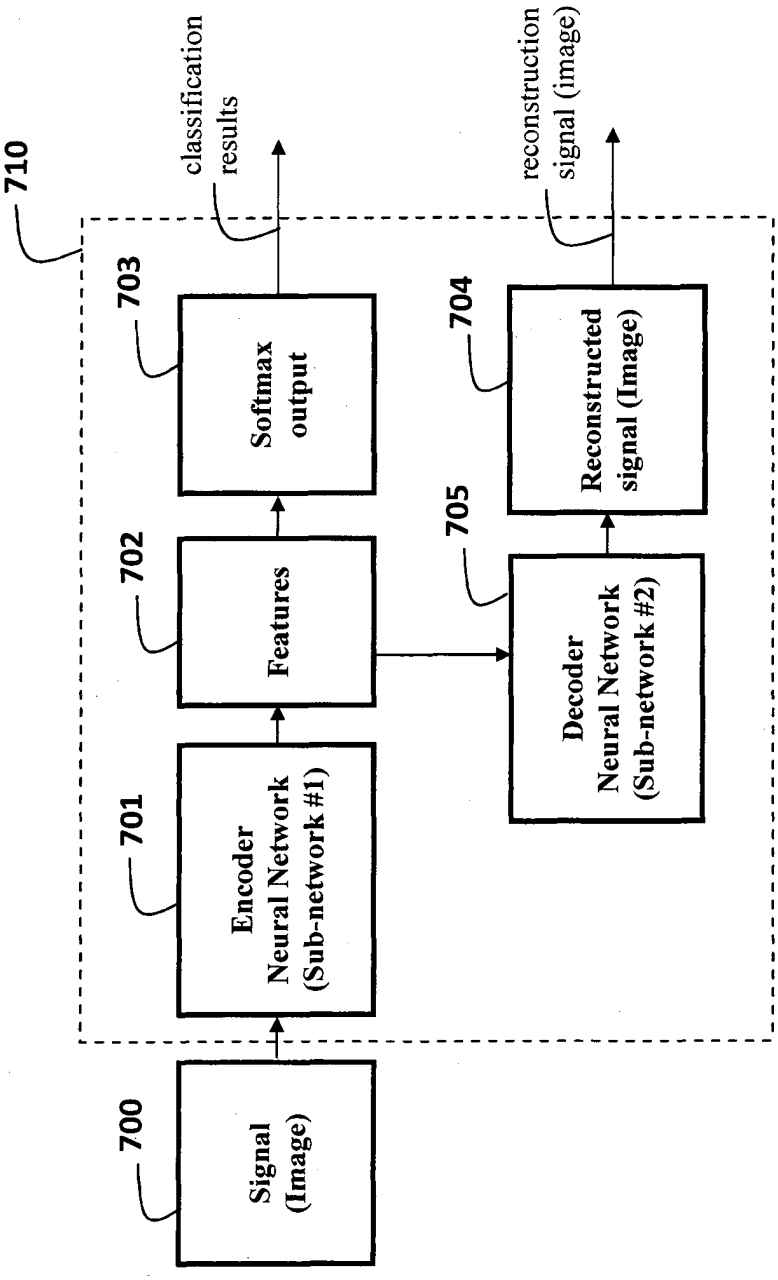
710
classification results
reconstruction signal (image)
703
Softmax output
704
Reconstructed signal (Image)
705
702
Features
Decoder Neural Network (Sub-network #2)
701
Encoder Neural Network (Sub-network #1)
700
Signal (Image)

FIG. 3

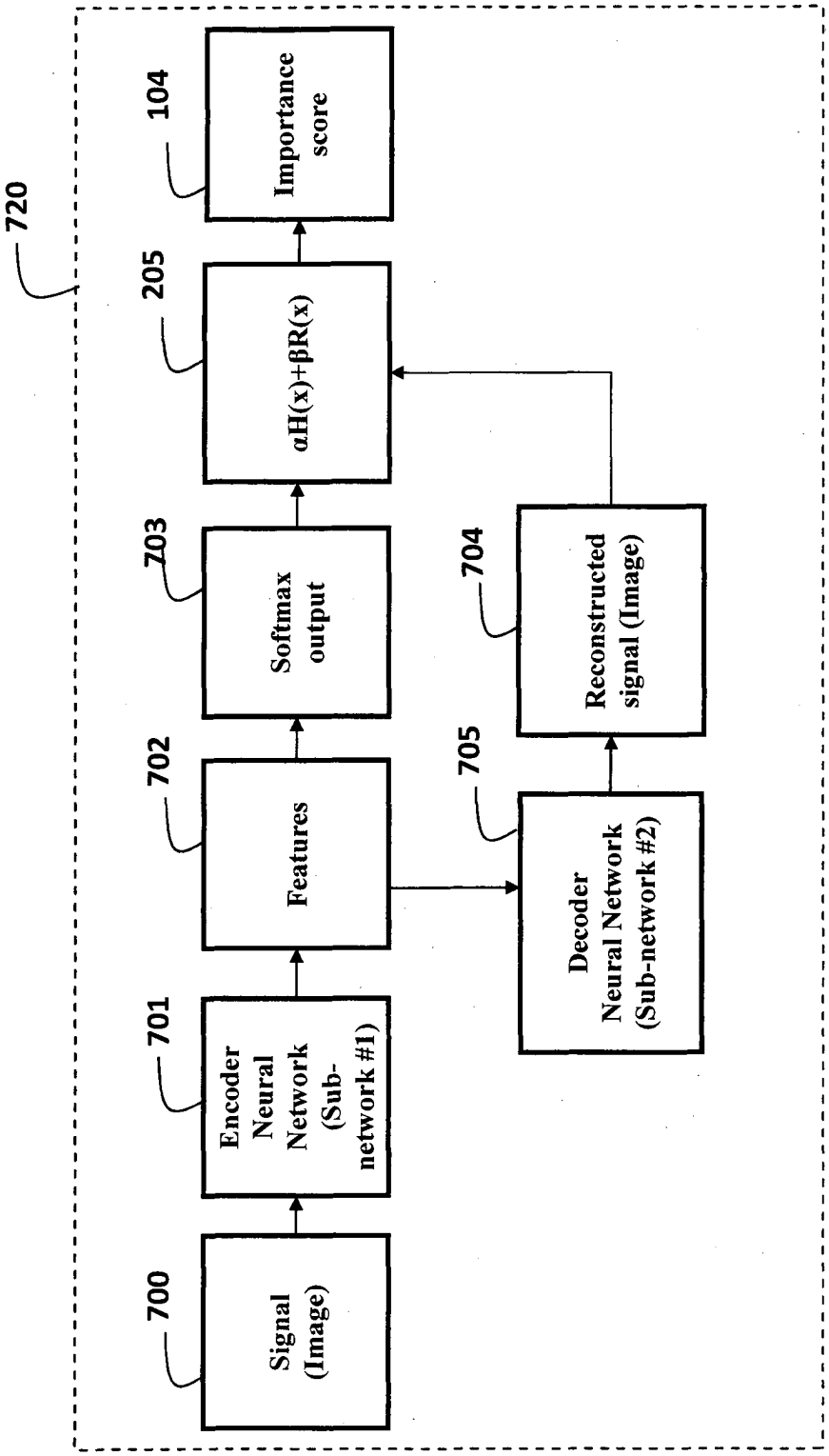
720
700
Signal (Image)
701
Encoder Neural Network (Sub-network #1)
702
Features
703
Softmax output
205
αH(x)+βR(x)
104
Importance score
705
Decoder Neural Network (Sub-network #2)
704
Reconstructed signal (Image)

FIG. 4

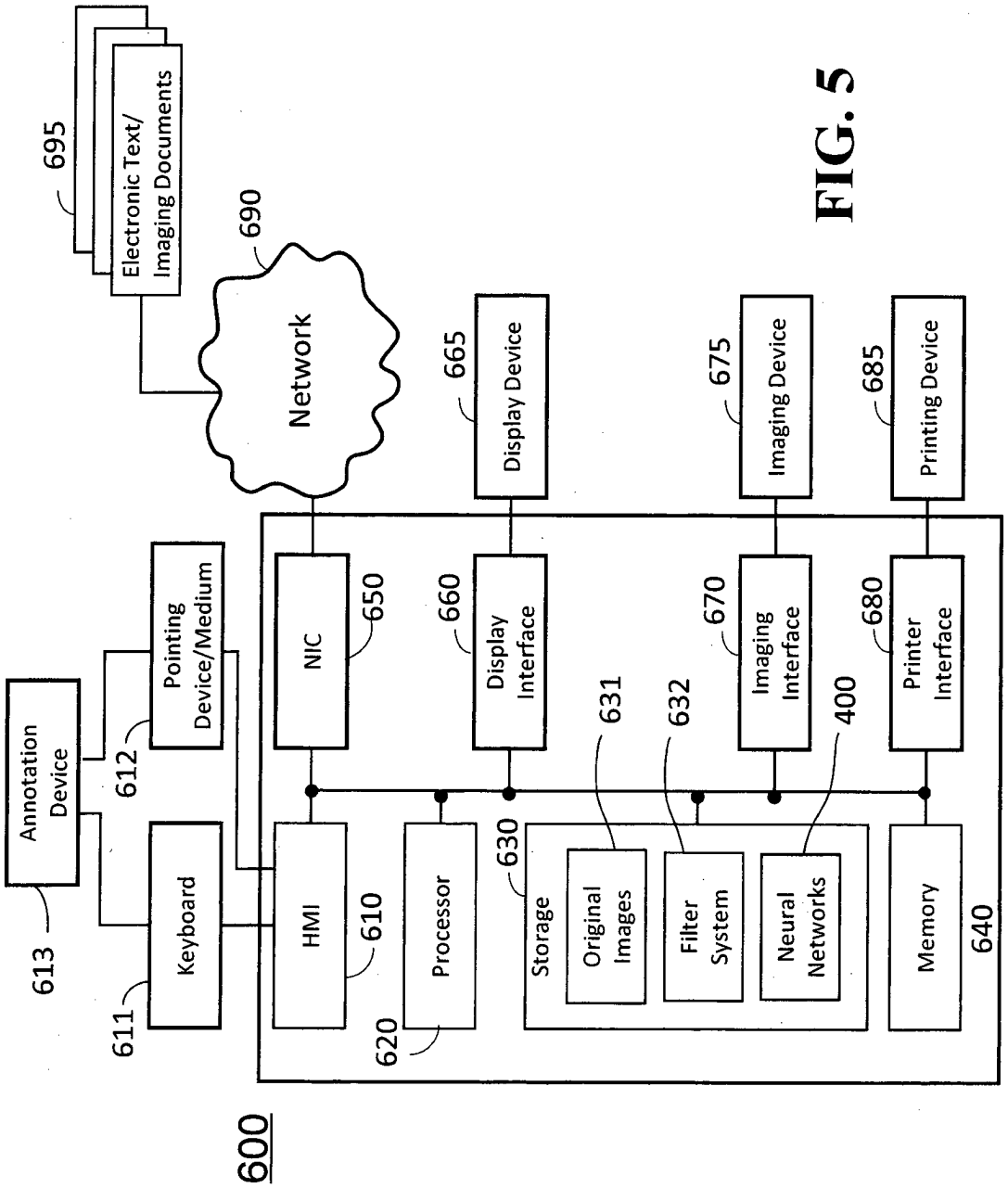
600
Annotation Device
613
Keyboard
611
Pointing Device/Medium
612
HMI
610
NIC
650
Network
690
695
Electronic Text/ Imaging Documents
Processor
620
Storage
630
Original Images
631
Filter System
632
Neural Networks
400
Display Interface
660
Display Device
665
Imaging Interface
670
Imaging Device
675
Printer Interface
680
Printing Device
685
Memory
640

FIG. 5

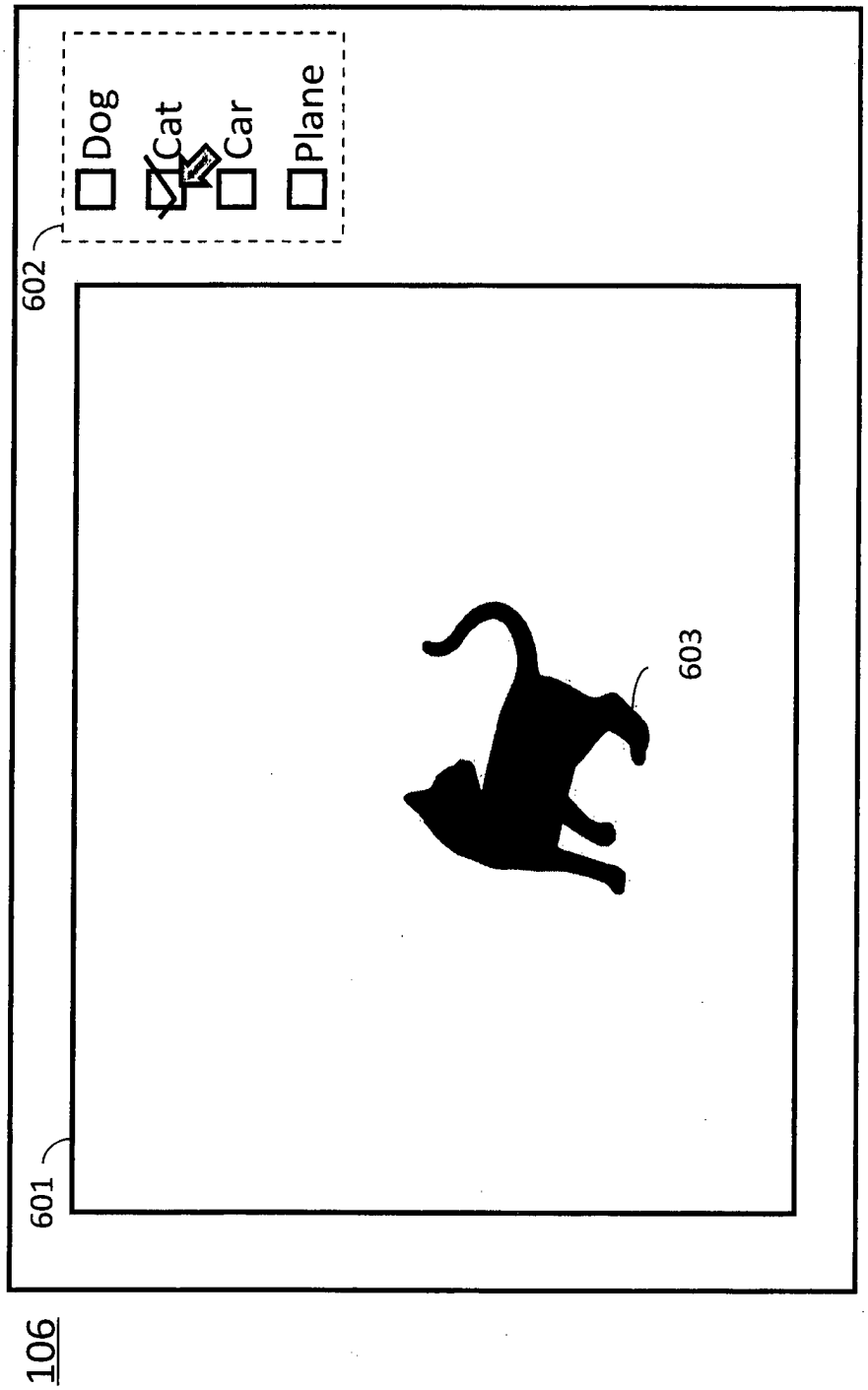

FIG. 6

Dataset	Uncertain .meas. & Recon.	RDM	EMC	UNC	DW	FF
MNIST	98.87%	96.12%	98.77%	98.26%	98.74%	96.51%
CIFAR10	56.27%	52.92%	53.30%	53.87%	54.08%	51.98%

FIG. 7