FIG. 1

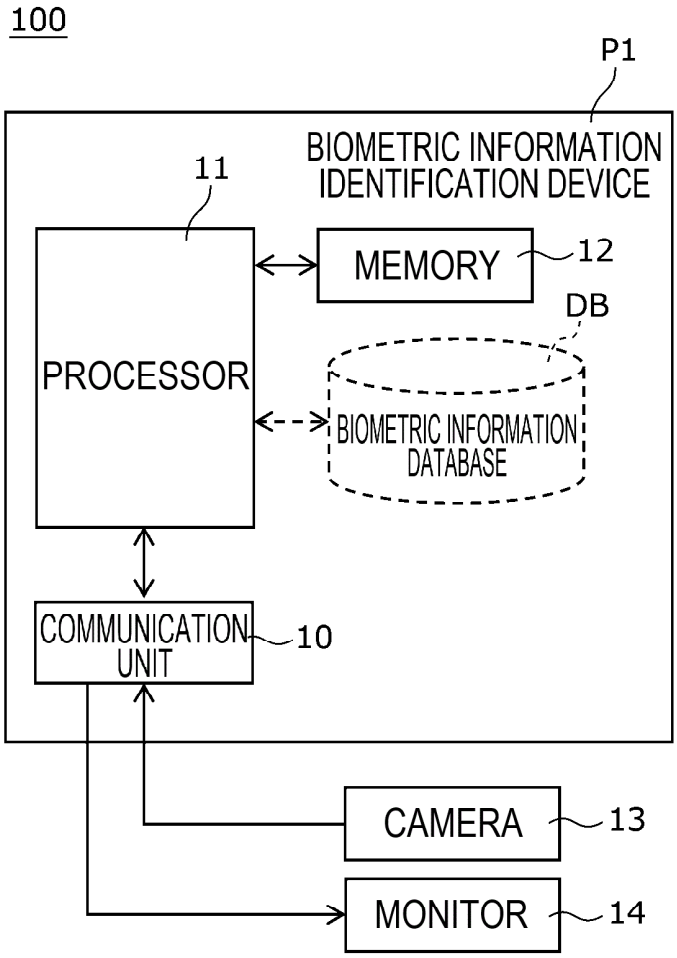

100
P1
BIOMETRIC INFORMATION IDENTIFICATION DEVICE
11
PROCESSOR
MEMORY
12
DB
BIOMETRIC INFORMATION DATABASE
COMMUNICATION UNIT
10
CAMERA
13
MONITOR
14

FIG. 2

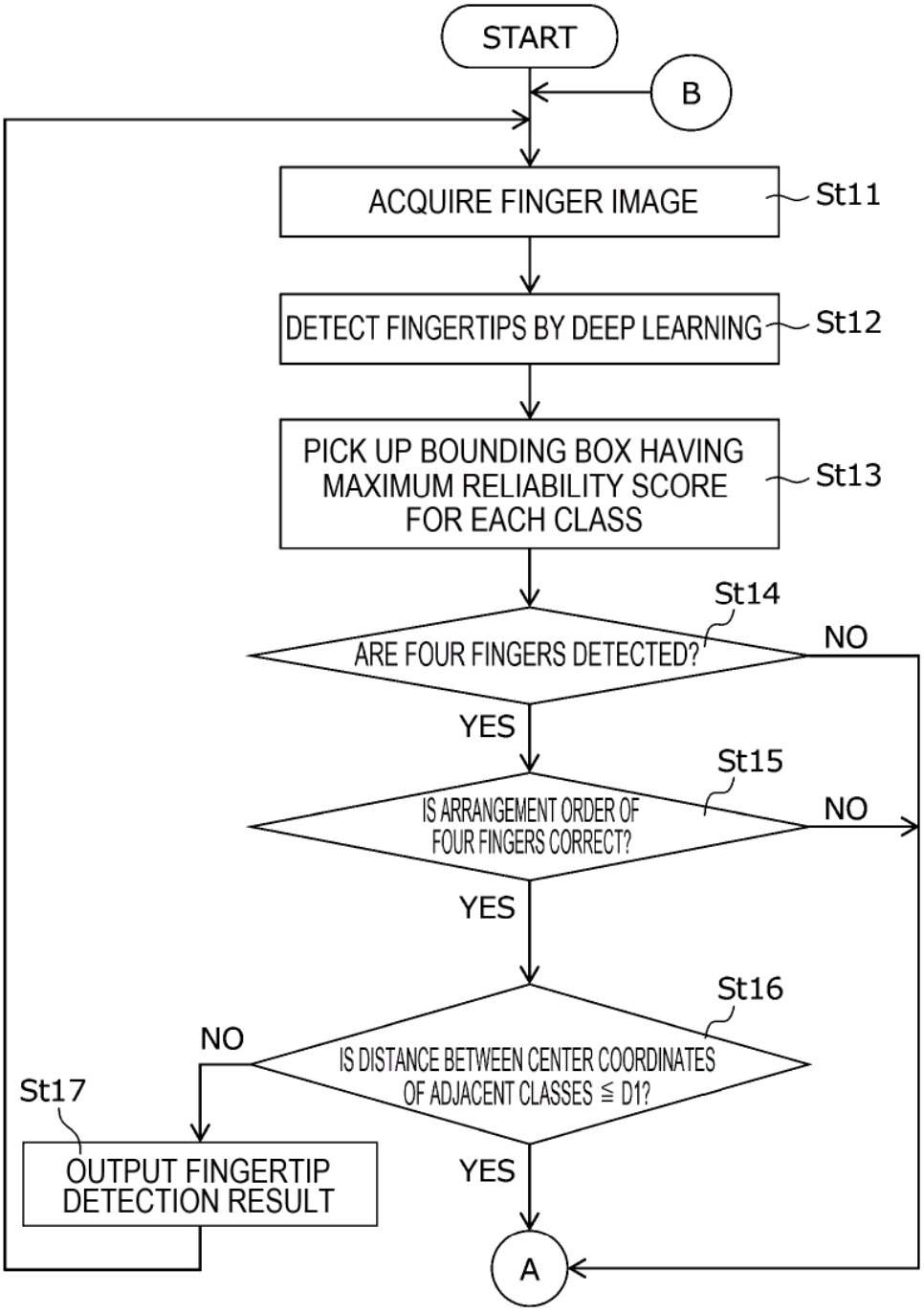

START
B
ACQUIRE FINGER IMAGE
St11
DETECT FINGERTIPS BY DEEP LEARNING
St12
PICK UP BOUNDING BOX HAVING MAXIMUM RELIABILITY SCORE FOR EACH CLASS
St13
St14
ARE FOUR FINGERS DETECTED?
NO
YES
St15
IS ARRANGEMENT ORDER OF FOUR FINGERS CORRECT?
NO
YES
St16
IS DISTANCE BETWEEN CENTER COORDINATES OF ADJACENT CLASSES ≦ D1?
NO
St17
OUTPUT FINGERTIP DETECTION RESULT
YES
A

FIG. 3

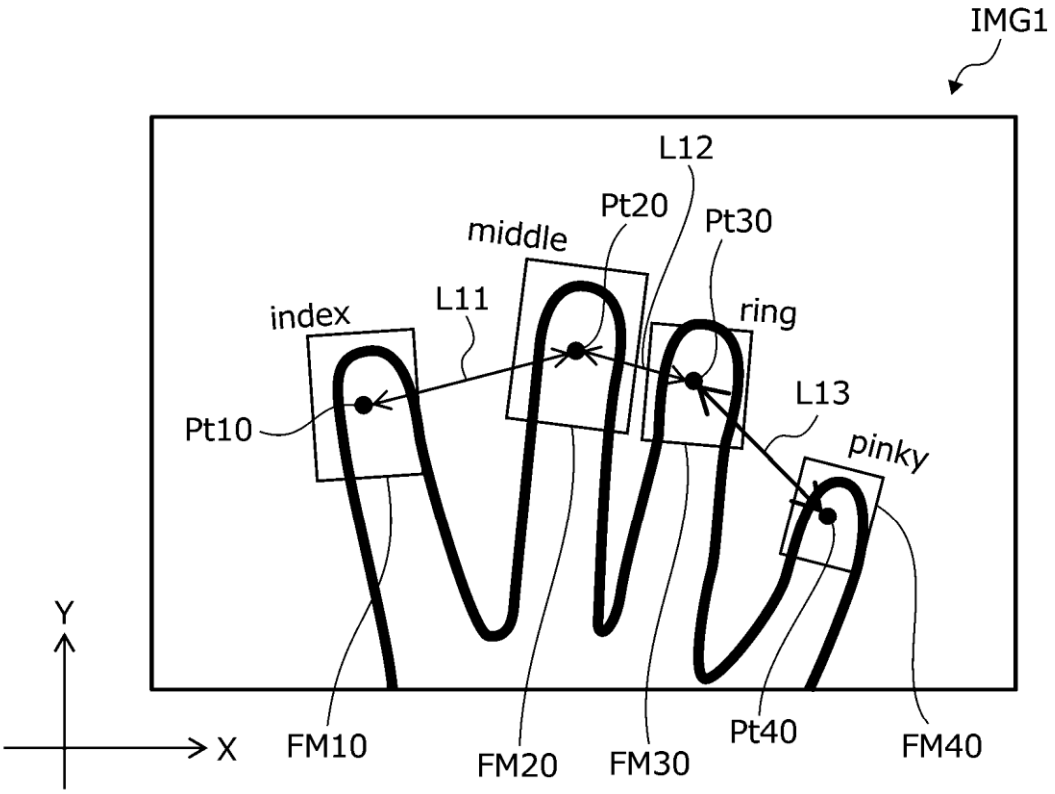

IMG1
L12
Pt20
Pt30
middle
index
L11
ring
L13
Pt10
pinky
Y
X
FM10
FM20
FM30
Pt40
FM40

FIG. 4

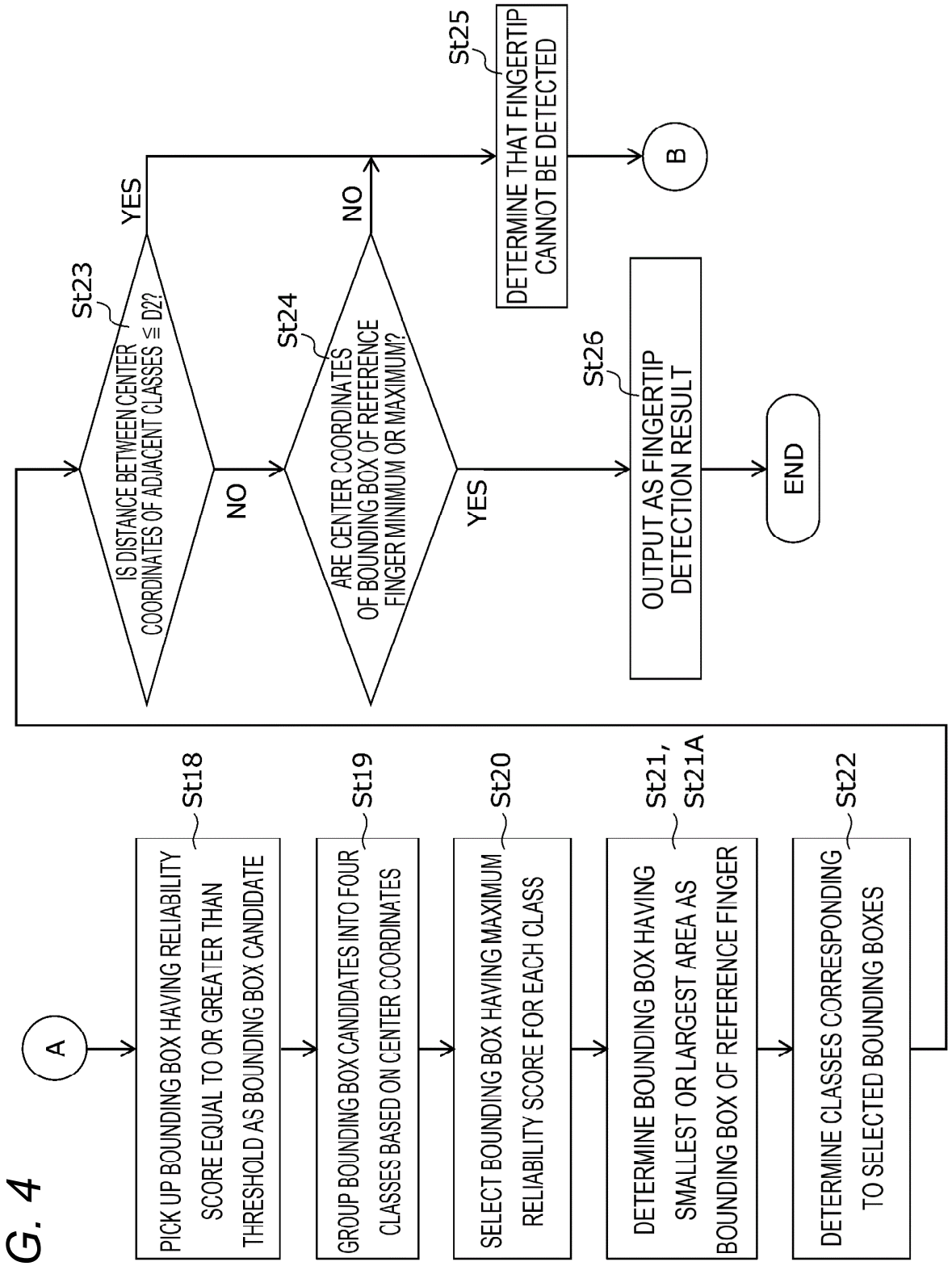

A
PICK UP BOUNDING BOX HAVING RELIABILITY SCORE EQUAL TO OR GREATER THAN THRESHOLD AS BOUNDING BOX CANDIDATE
St18
GROUP BOUNDING BOX CANDIDATES INTO FOUR CLASSES BASED ON CENTER COORDINATES
St19
SELECT BOUNDING BOX HAVING MAXIMUM RELIABILITY SCORE FOR EACH CLASS
St20
DETERMINE BOUNDING BOX HAVING SMALLEST OR LARGEST AREA AS BOUNDING BOX OF REFERENCE FINGER
St21, St21A
DETERMINE CLASSES CORRESPONDING TO SELECTED BOUNDING BOXES
St22
IS DISTANCE BETWEEN CENTER COORDINATES OF ADJACENT CLASSES ≦ D2?
St23
YES
NO
ARE CENTER COORDINATES OF BOUNDING BOX OF REFERENCE FINGER MINIMUM OR MAXIMUM?
St24
NO
YES
DETERMINE THAT FINGERTIP CANNOT BE DETECTED
St25
B
OUTPUT AS FINGERTIP DETECTION RESULT
St26
END

FIG. 5

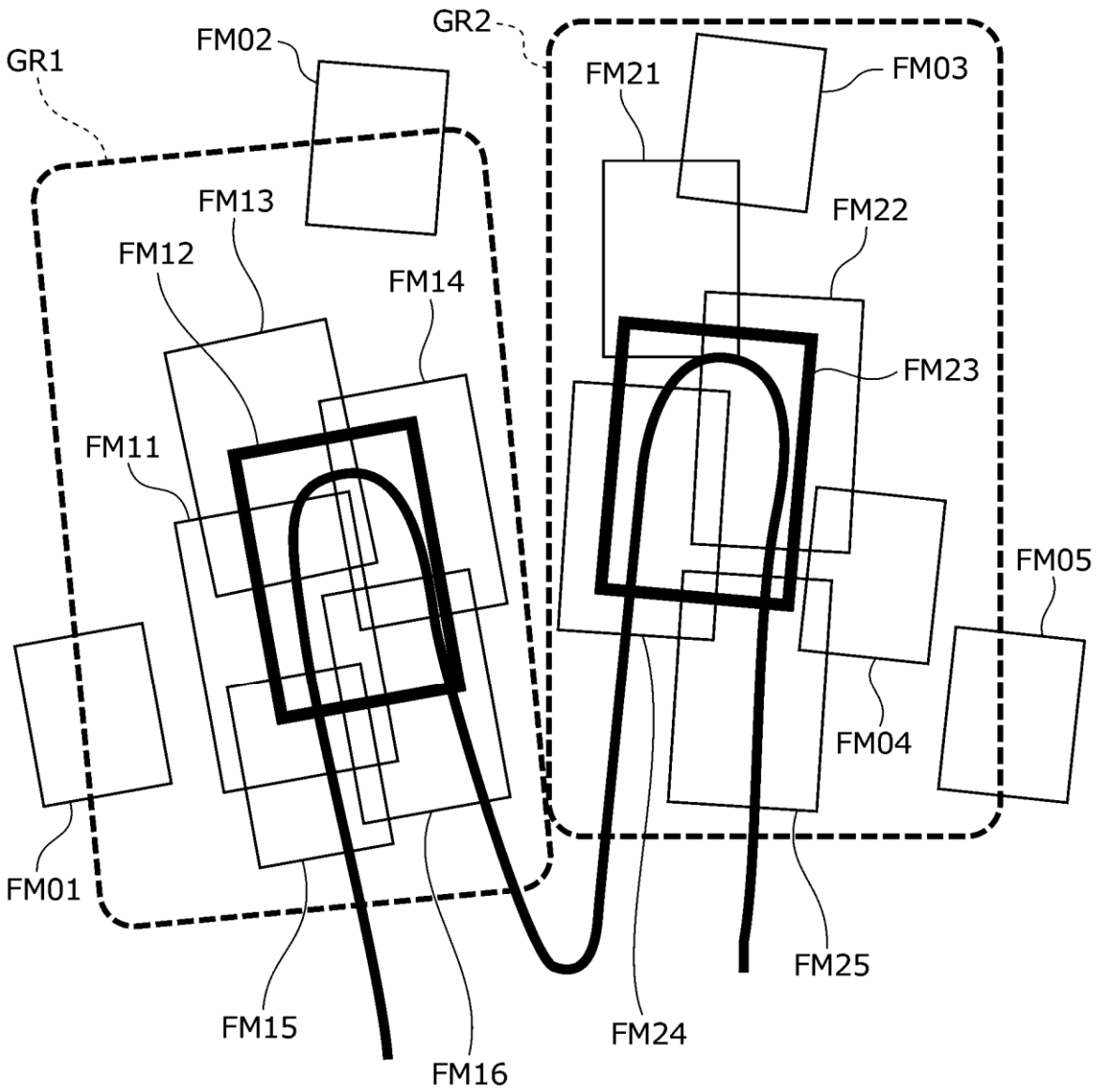

GR1
FM02
GR2
FM21
FM03
FM13
FM22
FM12
FM14
FM23
FM11
FM05
FM04
FM01
FM25
FM15
FM24
FM16

FIG. 6

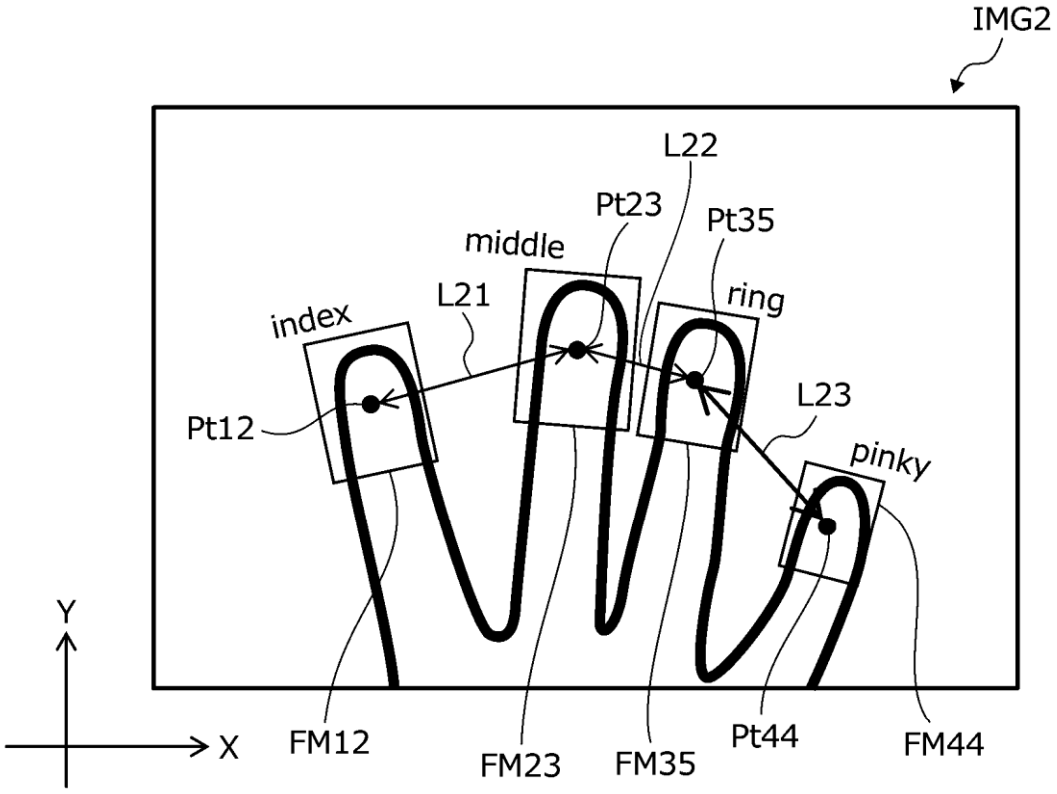
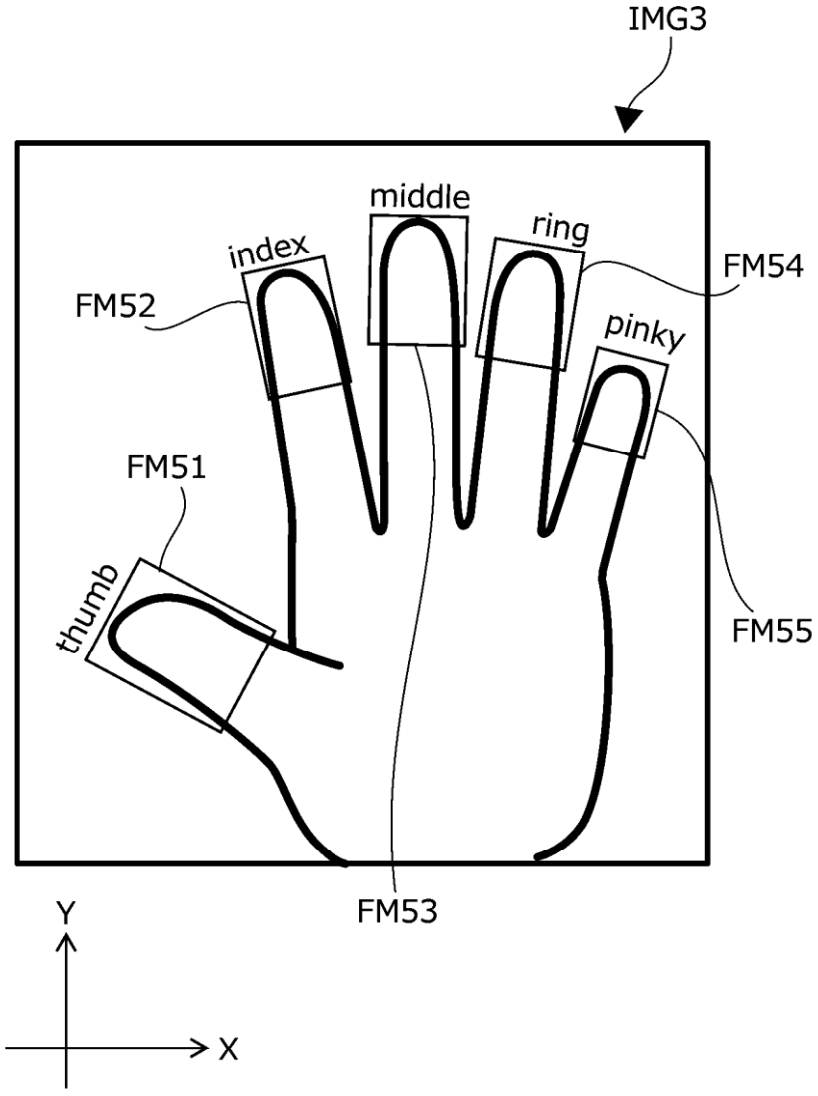

IMG2
L22
Pt23
Pt35
middle
ring
index
L21
L23
Pt12
pinky
Y
X
FM12
FM23
FM35
Pt44
FM44

FIG. 7


IMG3
middle
index
ring
FM54
FM52
pinky
FM51
thumb
FM55
FM53
Y
X