FPC

( ),   (   ),   ,   (   )

Automatic Punching System using Machine Vision for FPC

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ABSTRACT

This paper is about the development of automatic FPC(flexible printed circuit) punching instrument for the improvement of working condition and cost saving. FPC is used to detect the contact position of keyboard and button like a cellular phone. Depending on the quality of the printed ink and position of reference punching point to the FPC, the resistance and current are varied to the malfunctioning values. The size of reference punching point is 2mm and the above. Because the punching operation is done manually, the accuracy of the punching degree is varied with operator's condition. To improve this manual punching operation to the FPC, automatic FPC punching system is introduced. Test algorithms and programs showed good results to the designed automatic punching system and led to the increasement of productivity and huge cost down to law material like FPC by avoiding bad quality.

Key Words : FPC (Flexible printed circuit), Web camera(   ), Punching machine(   ), Position control(   ), Lighting system(   )

1.   .

FPC(flexible printed circuit)   , X-Y   ,   3
                              . ,   .   FPC
          (key top)   , X-Y
              PS/2
              .   FPC   X-Y   .   ,
                    .   FPC
              ,   .   X-Y
                    FPC
              ,   .
                                                      RS232C   FPC
        .   .   FPC
      .   0.5~5mm   ,
                                                                                                    .
          ,
                    ,   **2.**
                          .
                    ,
                                                          .

(frame grabber)　A/D

DLL　Active X

,

.

2.1 (erosion)

．　A

B　　　　　　2

．

B　　　　A　　　　b　B
c+b　A　　　c　　　　　　．

A⊖B = {c|c+B　A for every b　B}
or
A⊖B = {c|c=a-b for every b　B}　　　　(1)

, a={a₁, a₂… ,aₙ}, b={b₁, b₂…, bₙ},
⊖　　　　　　　　　　　　　　．

2.2 (dilation)

B
A　　c=a+b　　　　c
．

A⊕B = {c|c=a+b for some a　A and b　B}
or
A⊕B = ⋃ₓ ∈ B A+x　　　　　　　　(2)

, a={a₁, a₂…, aₙ} b={b₁, b₂…, bₙ},
⊕　　　　합을　　　．

3.

3.1

ROI
．

$$\bar{x}=\frac{\sum_i^N x_i}{N}, \quad \bar{y}=\frac{\sum_i^N y_i}{N} \qquad (3)$$

, x_i　　　　　x　, y_i　　　　　y　,
N　　　　　　　．

3.2

r　　　　　(x_0, y_0)
．

$$(x_i-x_0)^2+(y_i-y_0)^2=r^2 , i=1,\cdots,n \qquad (4)$$

, n　　　　　　　　, (x_i, y_i)
x, y　　　．　(4)

$$E=\sum_{i=1}^{n}[(x_i-x_0)^2+(y_i-y_0)^2-r^2]^2$$
$$=\sum_{i=1}^{n}(x_i^2-2x_i x_0+y_i^2-2y_i y_0+z)^2 \qquad (5)$$
여기서, $z=x_0^2+y_0^2-r^2$

(6)　　　　　　　　　,　　　　　　　r
(x_0, y_0)　　　　　　．

$$-\frac{\partial E}{\partial x_0}=\sum_{i=1}^{n}(x_i^2-2x_i x_0+y_i^2-2y_i y_0+z)(-2x_i)=0$$
$$-\frac{\partial E}{\partial y_0}=\sum_{i=1}^{n}(x_i^2-2x_i x_0+y_i^2-2y_i y_0+z)(-2y_i)=0$$
$$-\frac{\partial E}{\partial z_0}=\sum_{i=1}^{n}(x_i^2-2x_i x_0+y_i^2-2y_i y_0+z)=0 \qquad (6)$$

4.

4.1 3

Pro/E CAD
물을 이용하여 3　　　　　　．　Fig.1
．
, FPC

,

．

4.2

(2mm, 3.5mm, 4mm)　　　　　,
FPC
．　,
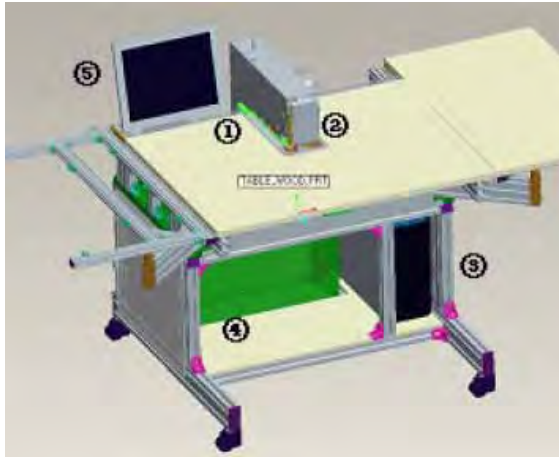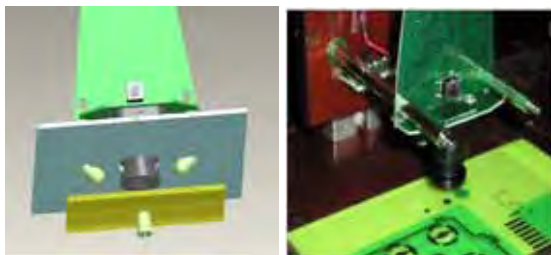
Fig.1 3D model of vision punching machine, ① punch & die, ② CCD camera, ③ computer, ④ controller, ⑤ LCD monitor.

, foot   .
                        ROI(region of interest),   ,

                                            ,
                                    .
                        2
                                    ,
                    .
        (0,0)   x, y
            ,   RS232C
                                    .

                    .   ,
                    .

        (a) 3D view   (b) actual photo
Fig. 2 FPC setting position to the camera & LED to calculate the center of circle

4.3

                    .
        LED   .   FPC

                        ,   FPC

                                    .

4.5

    Fig. 3   .
                            (1   10:   )
                            ,
                                (regulator)
                        .   50
kgf   ,   10
    500 kgf   .
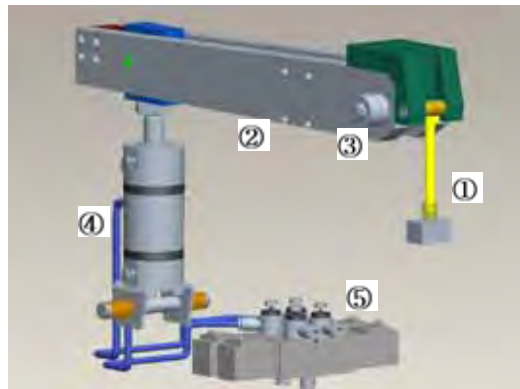

Fig. 3 3D view of punching mechanism, punching parts,   lever,   lever pin, pneumatic cylinder,   solenoid valve & speed controllers.

5.

    Fig. 4   ,
                            [Fig.4(a)]
        y   3   [Fig.4(b), (c)].

                        [Fig.4(d)]   [Fig.4(e)]
                ,   ,
                            [Fig.4(f)]
                    .
Fig.5(a)
                        ,
        .
                            ,

    .   , Fig.5(c)   Fig.5(a)

    .   ROI
                    X-Y
    . Fig.6(b)   Fig.5(a)
                    .   , X-Y
                                    .

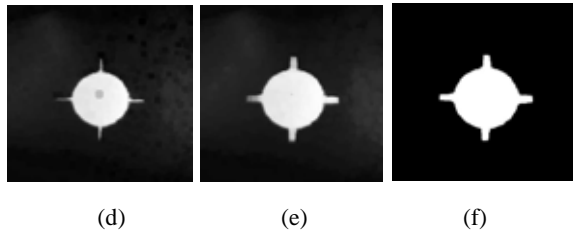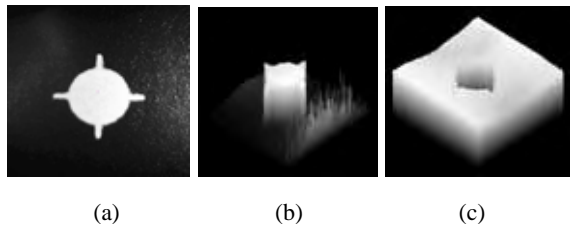(a)   (b)   (c)

(d)   (e)   (f)

Fig. 4 Image processing procedure for removing the noise of captured image. (a) original image, (b) 3D view of original image, (c) inverse 3D view of original image, (d) by erosion calculation, (e) dilation calculation, (f) multiplication and threshold.
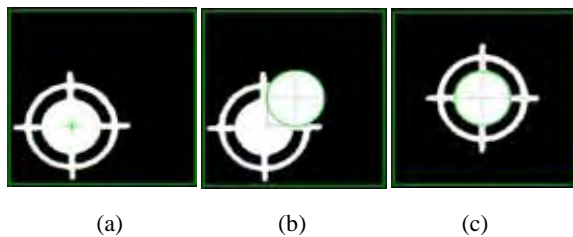
(a)   (b)   (c)

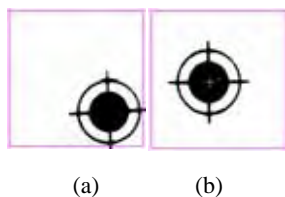Fig. 5 Image of punched FPC, (a) calculated center position by moment method, (b) manual mode, (c) automatic mode.

(a)   (b)

Fig. 6 Decision the center position of circle in ROI, (a) on boundary line, (b) within boundary.

Fig. 6

.

ROI   ,

.   foot

,   .

6.

,   X-Y

,

.

.

1.

       FPC

       30%   ,

.

2.

       1.5   ,

.

3.

       AVR   (ATmega128)
RS232C

.

(MRC)

.

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