Classification of Pen-based Computers based on the Space Structures

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Abstract:

This article first introduces the pen-based computers' input properties, and then gives a new method to classify the states of pen-input computers according to the pen-tablet physical space structure. Both considering the latest developed functionality of the pen-based computer system and the practical issue of those states, it checks all states in depth. At the same time, a comprehensive permutation and combination table helps to explain the different states in details. Finally, this article provides a unique model to include all the states the pen-based computer can reach.

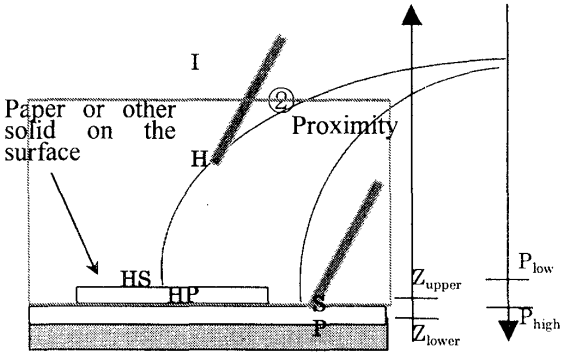
Key Word:

Pen-based Computers, Space Structure, Classification

1.Research Aim:

Our long-term goal is to design and produce a standardized file format of ink data for pen-based computers. The purpose of this paper is to show that an existing pen-based computer can be classified into one of 15 types of pen-based computers. Those who engage in designing a pen-based system have a strong desire for a standardized file format of ink data in order for storing and sending/receiving them. However, no such file format exists. Because of the lack of the standardized format, most of designers of pen-based system are forced to employ the method to convert ink data to image data for sending and/or receiving them. Once a standardized file format is in our hand, we expect that such systems as pen-input e-mail, pen-input chat and pen-input contents system will be wide-spread. We described in the former paper a model (called a physical model) which depicts the functions of pen-input hardware. Once we could build such unified physical model as any one of pen-based computers can be identified on the unified model, the model can lead to design a standardized file format of ink data. Moreover, the software build based on the unified model can be an input-component for every pen-based computer.

2.The Parameter Threshold Used to Distinguish:



In the above figure, the left is the tablet. In the right the two axes just take the opposite direction, Z_{upper} is just above the upper plane of the layer on the tablet and Z_{lower} is just below that plane. The P_{low} is largely depend on the concrete hardware how much is the Pressure by the slightest touch on the tablet. And a pressure between P_{low} and P_{high} is served to give a range to help the user to gain some special effect, such as a constant pressure output when they are doing something like sketch.

3.Basic Classification of Input States:

The input states is given as following, 7 of them in total:

1.Invalid : where the pen is out of the detectable proximity of the tablet;

2.H : $Z>Z_{upper}$ and Pressure$<P_{low}$;

3.HS : $Z>Z_{upper}$ and P_{low}<Pressure$<P_{high}$;

4.HP : $Z>Z_{upper}$ and Pressure$>P_{high}$;

5.P :$Z_{lower}<Z<Z_{upper}$ and Pressure$>P_{high}$

6.S :S_h or S_P where

S_h: $Z_{lower}<Z<Z_{upper}$ and Pressure$<P_{low}$

S_p: $Z_{lower}<Z<Z_{upper}$ and P_{low}<Pressure$<P_{high}$

7.H_{nul} :(when height function is not implemented in the tablet) Pressure$<P_{low}$ and the pen do not touch the tablet

	$Z<Z_{lower}$	$Z_{lower}<Z$ $Z<Z_{upper}$	$Z_{up}<Z$
$P<P_{low}$	N/A	S_h	H
$P_{low}<P<P_{high}$	N/A	S_p	HS
$P_{high}<P$	N/A	P	HP

Another effect is brought by the so-called Tip Switch (Tsw for abbreviation).This Tip have two states: On and Off. So the 6 states will be doubled into 12 states the pen can demonstrates:

Some states will be existing but have no meaning to the operation, as to these cases a useless collection is given to hold them:

Space States	TipSw		No TipSW
	On	Off	N/A
I	IT_{on}	IT_{off}	I
H	HT_{on}	HT_{off}	H
HS	HST_{on}	HST_{off}	HS
HP	HPT_{on}	HPT_{off}	HP
P	PT_{on}	PT_{off}	P
S	ST_{on}	ST_{off}	S
H_{nul}	$H_{nul}T_{on}$	$H_{nul}T_{off}$	H_{nul}

4. Permutation and Combination of the Basic States:

(a)Two-dimension states case:

The very basic states is Invalid, Surface, Height, Pressure and Hnul space. From them, HS and HP can be derived as follows:

	I	H	S	P	H_{nul}	T_{sw}
I						
H	---①					
S	---①	HS				
P	---①	HP	---④			
H_{nul}	---①	---②	$H_{nul}S$	$H_{nul}P$		
T_{sw}	---①	HT_{sw}	ST_{sw}	PT_{sw}	$H_{nul}T$	

(b)Three-dimension states case:

	I	H	S	P	H_{nul}	Tsw
HS	①	---	---	④	②	HST_{sw}
HP	①	---	④	---	②	③
$H_{nul}S$	①	②	---	④	---	$H_{nul}ST$
$H_{nul}P$	①	②	④	---	---	$H_{nul}PT$
HT_{sw}	①	---	HST_{sw}	③	②	---
ST_{sw}	①	HST_{sw}	---	③	$H_{nul}ST$	---
$H_{nul}T_{sw}$	①	②	$H_{nul}ST$	③	---	---

There are several criteria to govern the intersection of those states:

① Invalid State is obvious not able to intersect with other states than Invalid.

② H state and H_{nul} state are exclusive.

③ Tsw P = ; Because up to now, no manufacture provided such a device;

④S state and P state can not be mixed because a pressure threshold lies between them

(c)Four-dimension states case:

	I	H	S	P	H_{nul}	Tsw
HST_{sw}	①	---	---	③	②	---
$H_{nul}ST_{sw}$	①	②	---	③	---	---
$H_{nul}PT_{sw}$	①	②	④	③	---	③

5.Conclusion of the Input States:

So now the number of total states is 15 kinds:

1-D: I, H, S, P, H_{nul} (5 kinds)

2-D: HS, HP, $H_{nul}S$, $H_{nul}P$, HTsw, STsw, H_{nul}Tsw (7 kinds)

3-D: HSTsw, H_{nul}STsw, H_{nul}PTsw (3 kinds)

When the height information is not available, please refer to the tablet in the below:

The outmost space is Invalid state, then the Hnul state, and the S state is the same as before. When the pen, for example, on paper lying on the tablet, the pressure will be passed to tablet, which leads to the $H_{nul}P$ state.

$Pressure<P_{low}$	S
$P_{low}<Pressure<P_{high}$	$H_{nul}S$
$P_{high}<Pressure$	$H_{nul}P$

6.Reference:

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