COIN ANALYSIS ON PUNCHED CARD MACHINE TYPE IBM 101

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SUMMARY. A method of coin analysis on Electronic Statistical Machine Type IBM 101 is described in this paper. The method is faster and more economic than other punched card methods.

1. INTRODUCTION

Any transaction in cash involves notes and coins of various denominations. A money disbursing centre that makes a large number of individual payments is therefore interested not only in knowing the total amount of money to be disbursed, but also the number of notes and coins in which this amount should be available, so that all the individual payments can be made directly. This breakdown of the total amount of money into the appropriate number of notes and coins of various denominations is known as Coin Analysis. A lot of time and unnecessary trouble to both the money disbursing authorities and the payees at the time of payment can be saved if coin analysis of the amount is available.

2. THE COIN ANALYSIS TABLE

Consider a 6 digit amount where the last two digits are allotted for the naye paise part. Thousandth and hundredth position of the rupee part gives the number of 100-rupee notes involved in the amount and the number of 10 rupee notes involved is decided by the tenth position of the rupee part.

The number of rupee notes of denominations 5, 2 and 1 has to be decided by the unit's position of the rupee field. If it is greater than or equal to 5, it means that the number of 5-rupee notes involved is one. Similarly the number of 2-rupee notes involved is one if the amount is 2,3,7 or 8 whereas the number will be two if the amount is 4 or 9. It is quite clear that one 1-rupee note is involved in the amounts 1, 3, 6 or 8. Naye paise also can be broken down in coins of 50, 25, 10, 5, 2 and 1 in a similar fashion. This breakdown of amount in denominations of notes and coins can be shown neatly in the following tabular form.

Let x denote the unit's position of the rupee part; y, the ten's position of the naye paise part and z, the unit's position of the naye paise part. The number of notes and coins required for any payment upto Rs. 9.99 is determined by the following rules :

COIN ANALYSIS TABLE

amount	number involved	condition	
notes			
Rs. 5	1	$x \geqslant 5$	(1)
Rs. 2	1	$x = 2, 3, 7$ or 8	(2)
	2	$x = 4$ or 9	(3)
Re. 1	1	$x = 1, 3, 6$ or 8	(4)
coins			
50 nP	1	$y \geqslant 5$	(5)
25 nP	1	$y = 2$ or 7 with $x \geqslant 5$	(6)
		$y = 3, 4, 8$ or 9	(7)
10 nP	1	$y = 1$ or 0	(8)
		$y = 3$ or 8 with $x \geqslant 5$	(9)
		$y = 4$ or 9 with $x \leqslant 4$	(10)
	2	$y = 2$ or 7 with $x \leqslant 4$	(11)
		$y = 4$ or 9 with $x \geqslant 5$	(12)
5 nP	1	$y = 0, 1, 5$ or 6 with $x \geqslant 5$	(13)
		$y = 3, 4, 8$ or 9 with $x \leqslant 4$	(14)
2 nP	1	$z = 2, 3, 7$ or 8	(15)
	2	$z = 4$ or 9	(16)
1 nP	1	$z = 1, 3, 6$ or 8	(17)

To every condition that is satisfied by the amount, we have to take the corresponding denominations of notes or coins in the required number's. The following example will explain this clearly.

Consider the amount Rs. 1439.93. Evidently the number of 100-rupee notes involved in the amount is 14 whereas that of 10-rupee notes is 3. Here, $x = 9$; $y = 9$; $z = 3$.

Now, $x = 9$ satisfies the condition $x \geqslant 5$. Clearly one 5 rupee-note is involved. Moreover it satisfies the condition $x = 4$ or 9 also. Hence two 2-rupee notes also are involved in the amount. Coming to the naye paise part, we see that $y = 9$ $z = 3$ satisfy the conditions

$$y \geqslant 5.$$

$$y = 3, 4, 8 \text{ or } 9$$

$$y = 4 \text{ or } 9 \text{ with } z \leqslant 4$$

$$y = 3, 4, 8 \text{ or } 9 \text{ with } z \leqslant 4$$

$$z = 2, 3, 7 \text{ or } 8 \text{ and}$$

$$z = 1, 3, 6 \text{ or } 8$$

Referring to the coin analysis table we find that 93 naye paise involves one 50np, one 25np, one 10np, one 5np, one 2np and one 1np coins. Thus for any amount we can find out the required number of notes and coins.

The principle explained above is the basis on which we have to instruct the computing machines for coin analysis.

When the number of individual payments is large it will be a laborious process to do coin analysis manually. Here the punched card system provides a swift and reliable method which saves a lot of time and lengthy work and gives the required information in neat tabulated forms.

3. Traditional methods of coin analysis on punched card machines

We have for each payment to be made a card on which the amount of payment and other relevant details are punched. This punched card is passed through the machines at various stages of processing.

Three methods are generally used for coin analysis. They are

Method 1 : Using Sorter, Gang Punch and Tabulator

Method 2 : Using Calculating punch and Tabulator

Method 3 : Using Tabulator only

In the first method, for each amount punched in the unit's position of the rupee field a master card is prepared punching the appropriate combination of the number of 5, 2 and 1 rupee notes involved in the amount. Evidently 9 master cards are to be prepared, one for each of the amount 1 to 9. Similarly 99 master cards one for each of the naye paise 1 to 99 also are to be prepared. Payment cards are sorted on unit's position of the rupee field and the corresponding master card is filed before each group. Using Gang Punch, the note combination is gang punched from the master card on the following group. Similar operation is done for the naye paise field also. After separating out the master cards, payment cards are tabulated on a tabulator to get the final coin analysis.

In the second method, for every card, proper combination of notes and coins is calculated by making use of the principle of the successive division on a Calculating Punch. These calculated cards can be tabulated as explained before.

In the third method, a tabulator is used. One counter is reserved for each type of note or coin and a selector is actuated for every condition mentioned in the coin analysis table. Then a '1' or '2' as is required is added to counters selectively and tabulated at every control level.

4. USE OF IBM ELECTRONIC STATISTICAL MACHINE TYPE 101

A novel method of doing coin analysis on the IBM Electronic Statistical Machine has been devised by the Data Processing Unit of the Research and Training School (ISI).

The ESM (IBM 101) is in effect a special selective counting sorter which can do selective counting with or without changing the order of the cards and print the result.

It has got 60 unit counters each of 4 positions. In each card cycle, a unit counter can add the digit '1' when instructed to do so. For adding the digit 1 in a unit counter we have to make use of a count impulse which is available at the Counter hubs. Each Count mechanism has got one "To" hub and one "Return" hub. A count impulse taken from "Count to" hub is wired to the "In" hub of a unit counter with or without filtering through (recode) selectors and is returned to the corresponding "Count Return" hub by wiring it (i.e. "Return" hub) to the "out" hub of the unit counter. Whenever this count impulse circuit is complete (i.e. "Count To" impulse returns to the "Count Return") the corresponding unit counter through which it passes adds the digit one.

A Recode Selector which is generally used to select a count or sort impulse has got two pairs of pick up hubs and 4 positions arranged vertically on the control panel. Each position has got a common hub, a normal hub and a transfer hub (The upper two positions have a pair of transfer hubs) and the connection of a common hub to the corresponding normal or transfer hub is determined by the impulses available at its recode pick up hubs. Whenever both the pick up hubs get impulses simultaneously that recode selector will be picked up for the following cycle and the common will be connected to the transfer throughout that cycle. When the pick up impulses are not like impulses (i.e. not simultaneous impulses) that recode selector will not be picked up in which case the connection will be between common and normal points. Hence a recode selector can be used to control the machine functions according to some pre-determined conditions. There are 60 such recode selectors equipped in the Electronic Statistical Machine.

There are 14 digit emitters in the ESM each of which serves the purpose of getting the impulses 9 through 12 mechanically.

To count the number of notes and coins involved in any payment we have to make use of recode selectors, unit counters and digit emitters.

Since a unit counter add only unity, whenever we have to add 2, two unit counters are to be used each adding unity, and the corresponding print fields have to be added manually on the tabulation sheet to get the required total. Allocation of

unit counters corresponding to the conditions given in the Coin Analysis table is done as shown below :

amount	number involved	condition		unit counters allocated
notes				
Rs. 5	1	$x > 5$	(1)	2
Rs. 2	1	$x = 2, 3, 7$ or 8	(2)	3
	2	$x = 4$ or 9	(3)	3 & 4
Re. 1	1	$x = 1, 3, 6$ or 8	(4)	5
coins				
50 nP	1	$y > 5$	(5)	6
25 nP	1	$y = 2$ or 7 with $x > 5$	(6)	7
		$y = 3, 4, 8$ or 9	(7)	
10 nP	1	$y = 1$ or 6	(8)	8
		$y = 3$ or 8 with $x > 5$	(9)	
		$y = 4$ or 9 with $x < 4$	(10)	
	2	$y = 2$ or 7 with $x < 4$	(11)	8 & 9
		$y = 4$ or 9 with $x > 5$	(12)	
5 nP	1	$y = 0, 1, 5$ or 6 with $x > 5$	(13)	10
		$y = 3, 4, 8$ or 9 with $x < 4$	(14)	
2 nP	1	$x = 2, 3, 7$ or 8	(15)	11
	2	$x = 4$ or 9	(16)	12
1 nP	1	$x = 1, 3, 6$ or 8	(17)	13

Unit counter 1 is used for counting the total number of cards.

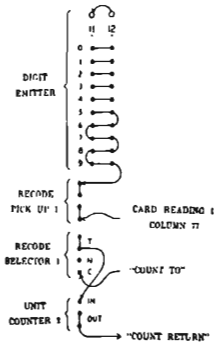
For each classification we can pick up a recode selector by giving digit emitter impulse and the first card reading impulse to its upper and lower pick up hubs corresponding to that classification. From the coin analysis table it is clear that one recode selector is required for each of the conditions 1, 2, 3, 4, 5, 7, 8, 15, 16 and 17 whereas the conditions 6, 9 ,10, 11, 12, 13 and 14 require two recode selectors each. Therefore on the whole 24 recode selectors have to be used.

Since there are 4 recode selector positions corresponding to a pair of recode pick up hubs of every recode selector we can reduce the number of recode selectors. Further economy in the use of recode selectors is possible by appropriately grouping them.

Suppose the selectors are picked up as shown below :—

condition	recode selector number
$x \geqslant 5$	1
$x = 2, 3, 4, 7, 8$ or 9	2
$x = 4$ or 9	3
$x = 1, 3, 6,$ or 8	4
$y \geqslant 5$	5
$y = 2$ or 7	6
$y = 3, 4, 8$ or 9	7
$y = 1, 4, 6$ or 9	8
$y = 3$ or 8	9
$y = 4$ or 9	10
$y = 0, 1, 5$ or 6	11
$z = 2, 3, 4, 7, 8$ or 9	12
$z = 4$ or 9	13
$z = 1, 3, 6$ or 8	14
$z \geqslant 5$	15

To pick up the selector number 1, we will give the digit impulses (5-9) from a digit emitter to one of the pick up hubs of the recode selector 1 and card column x, i.e.



unit's position o rupee field to the other pick up hub. Therefore whenever x is anyone of the digits 5, 6, 7, 8 or 9 selector 1 will transfer. A count impulse wired to the C hub of the recode selector 1 can be taken out of the T (transfer) hub whenever $x \geqslant 5$. This filtered count impulse is added in say-unit counter 2 to add unity. After passing

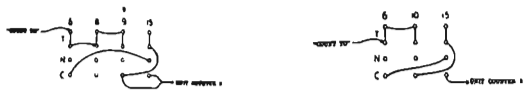
all the payment cards in the machine this unit counter will give the number of 5-rupee notes required for the payment. Following wiring diagram illustrates the counting of the number of 5-rupee notes. Let the payment be punched on card columns 74-79. Hence X, y and z corresponds to the card columns 77, 78 and 79 respectively.

Similarly through the C and T hub of the recode selector 2 which transfers when $x = (2-4)$ and $(7-9)$ corresponding to the conditions (2) and (3) a count impulse is added in the unit counter 3. Following the same principle using selector 3, 4th unit counter gives the number of additional 2-rupee notes required. Then adding manually the printed columns in the tabulated sheet corresponding to the unit counters 3 and 4, we get the total number of 2-rupee notes involved in the coin analysis. Counting of 1-rupee notes can be similarly done using 4th recode selector and 5th unit counter.

Counting of naye paise coins also is done using the same principle as explained before. As an example, consider the case of 10 naye paise coin. Here we have to use 4 recode selectors to select the y impulse (card reading 1, column 78) and another recode selector to select the z impulse (card reading 1, column 79). Selectors 6, 8, 9, 10 and 15 picked up in the following manner :

6	8	9	10	15
$y = 2$ or 7	$y = 1,4,6$ or 0	$y = 3$ or 8	$y = 4$ or 9	$z \geqslant 5$

Then the schematic diagram to get the count of 10nP coins will be as shown :



By adding the figures corresponding to the unit counters 8 and 9, we get the count of 10nP coins involved in the payment.

Instead of filtering the "count to" impulse through all the 4 selectors 6, 8, 9 and 15 we can filter a "12" impulse emitted from a digit emitter in the same way and this filtered impulse can be used to pick up a new recode selector by connecting it to its both pick up hubs. This new recode selector will transfer only if any one of the required conditions 8, 9, 10, 11 and 12 is satisfied. Now it is very easy to filter a count impulse, through this single new recode selector, before being sent to the unit counter 8. (Numerical field of the card will decide the condition of the selectors. Digit emitter impulse "12" will be emitted only after the complete reading of numerical field as well as 0, and x = zones. Hence its use here).

If we want the coin analysis for every group, we have to file 9 master cards at the end of every group which by appropriate panel wirint causes the machine to print after every group. Using a GI counter we get group indication also.

Though the speed of the machine is 450 cards per minute the operational speed is about 250-300 cards per minute. We could do the coin analysis of the payroll of about 1250 workers of Indian Statistical Institute belonging to about 35 sections in about 20 minutes.

Coin analysis in ESM is superior to other methods in many ways. In the sorter, gang punch and Tabulator method cards are to be passed thrice in sorter, (one run for sorting on units' position of rupee field and two runs for naye paise field) twice in gang punch (one for gang punching rupee denominations and other for naye paise denominations) and once in Tabulator. That is it requires 6 runs to get the final coin analysis. Calculating Punch and Tabulator method requires two runs. But Electronic Statistical machine gives the coin analysis in a single run. Compared to the speed of Calculating Punch (about 50 cards per minute) and of Tabulator (about 150 cards per minute), speed of ESM (about 450 cards per minute) is far greater. Moreover the sorting order of the payment cards will not be disturbed by passing them in ESM. Hence ESM is best suited for coin analysis.

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