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An Ergonomics Evaluation of Certain ATM Dimensions

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Although millions of automatic teller machines (ATMs) are currently used all over the world, users of ATMs still have usability problems including inappropriate user–ATM interaction, display problems and others. Many developed countries already have standards in place for ATMs. However, this is not the case in many other countries. This paper aims to assess certain dimensions of ATM machines and their suitability for users in Middle Eastern countries using anthropometric measurements of the user population taking Saudi Arabia as a case study. Dimensions of all ATMs used in Saudi Arabia were measured and compared with recommended dimensions based on anthropometric measurements of the user population. Results show that there is a mismatch between the dimensions of ATMs used in Saudi Arabia and the recommended dimensions based on the user population. Practical recommendations are given as to improve the usability of ATMs in Saudi Arabia and other Middle Eastern countries.

human–machine interaction automatic teller machines anthropometric measurements posture

1. INTRODUCTION

An automatic teller machine (ATM) is a computer-based interactive machine that offers several banking services. An ATM can be defined as a computer terminal activated by a magnetically encoded bank card allowing consumers to make deposits, obtain cash from bank accounts, pay bills, transfer money between accounts, print statements and do many other routine transactions as they would at a normal bank teller window [1]. Some U.S. banks have programmed their machines to offer ATM customers access to all banking services available on the bank's website, effectively duplicating the bank's website on the ATM display screen.

ATMs are known by various other names including automated transaction machines, automated banking machines, money machines, hole-in-the-wall, bancomats, multibancos and any time money machine [2]. To use an ATM, customers insert their ATM card into the machine and, using a touch-screen or keypad, enter a personal identification number (PIN) and specify the services desired. Customers can do many things round the clock on ATMs, e.g., deposit and withdraw banknotes, pay bills, deposit cheques, transfer funds [1, 2, 3].

The history of ATMs is open to debate since the cash dispenser's development occurred long before the machine itself was put into use. Most historians agree that Barclays in London was the

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first to deploy an ATM in 1967. It was not until the mid-1980s that ATMs started to gain wide acceptance. Then, there was an exponential increase in the number of ATMs. For example, the number of ATMs increased in Saudi Arabia from 462 with 16 million transactions in 1991 to 4842 with 205 million transactions in 2006 [4].

Having become an integral part of many societies around the globe, using the ATM can often be a frustrating experience. Among problems facing users are the ambiguity of menus, inappropriate user–ATM interaction, mismatch between ATM dimensions and anthropometric dimensions of users and the need to reinsert cards to conduct multiple transactions. This latter problem led Curran and King to study whether ATM menus were designed in an optimal manner [5]. They designed an ATM menu system (called Opti-ATM) which, they ascertained, outperformed navigation systems and was found to be more usable than existing ATM menus. The new system was designed to resolve the problem of users having to reinsert their ATM cards to carry out another transaction and to speed-up transaction times.

Body parts involved in using ATMs are shoulder, elbow, hand, wrist, neck and back. Although millions of ATMs are currently used all over the world, users of ATMs still have usability problems related to inappropriate ATM dimensions. ATMs cannot be designed with an adjustable range because of many reasons, e.g., the long time taken in doing the adjustments, the high degree of sophistication involved and the cost involved. In designing ATMs for the average user, it is expected that the design would not be appropriate for many users. Therefore, ATMs should be designed to accommodate almost all potential users.

A customer dealing with an ATM is a typical example of a human–machine system. A human–machine system can be simply defined as an arrangement of people and machines interacting with each other to achieve goals [6]. The basic features of any ATM are [1, 3]

- security: ATMs should be secure to prevent illegal transactions;
- information storage: ATMs are connected to bank networks for prompt information transfer;
- information processing: ATMs should authenticate the card used and the PIN before any transaction;
- the operation: after authentication, the ATM should do the required action (e.g., dispense cash, transfer funds, issue receipt).

It is recommended that workspaces are designed taking into consideration the shortest arm, posture and task requirements. The following work levels are thus recommended: (a) 50–100 mm above elbow height for delicate manipulative tasks; (b) 50–100 mm below elbow height for manipulative tasks involving a moderate degree of both force and precision (e.g., using ATMs); (c) 100–250 mm below elbow height for heavy manipulative tasks [6, 7, 8].

Very few published studies examined the issue of ATM dimensions and their suitability for users. For example, Coley, Wright, Park, et al. conducted a study in which 40 subjects, 18–65 years old, interacted with three different ATM simulations [9]. However, the authors only assessed the level of detail available on the screen and font colour, not the ATM dimensions or their suitability for users.

The interface the system presents to the user is often the most important factor in determining the success or failure of that system [10]. Interaction with ATM interface has previously been looked at from a number of different perspectives including age and gender. Thatcher, Shaik and Zimmerman indicated many difficulties in ATM use including having to wait in line to use the machine, poor visibility of the screen, difficulty in reaching the slots, the ATM running out of money and understanding what needs to be done on the ATM [10].

The design-for-all approach attempts to design products and workplaces that are suited to all members of the society. It is particularly concerned with including groups that might previously have not been considered, e.g., the old and those with disabilities [11]. Many databases exist that are concerned with human capabilities and in particular with anthropometry, but typically these

sources provide very limited information concerning people who are older and disabled. The effective support of design-for-all requires that data on human capability be presented in a form that matches design methods, which are now predominately three-dimensional and computer-supported.

As body measurements vary depending on gender, age and ethnic origin [7], ATMs must be appropriate for almost all potential users regardless of their characteristics. Many developed countries already have standards in place for ATMs. However, this is not the case in Middle Eastern and many other developing countries. This study aims to assess the suitability of certain ergonomics dimensions of ATMs taking Saudi Arabia as a case study. This assessment considers available anthropometric measurements of the Saudi adult population, who are at the same time the ATM user population. Another aim is to recommend ATM dimensions that will suit better the ATM user population in Saudi Arabia and be more comfortable. Anticipated benefits of this study include increasing the number of users, making these ATMs more user-friendly, minimizing difficulties facing users, improving customer satisfaction and increasing the speed of service. Another benefit is that results of this study are anticipated to help in developing standards for ATMs in countries like Saudi Arabia.

2. METHODOLOGY

Standards for ATMs already exist in some developed countries. For example, a standard for ATMs was developed in Australia; it gives ATM dimensions based on anthropometric measurements of the Australian population [12]. Figure 1 illustrates these dimensions. However, information solicited from Saudi Arabian Monetary Agency clearly indicates that there are no ATM standards in Saudi Arabia and individual banks are free to install ATMs with any reasonable dimensions. Due to the differences in population anthropometric measurements between countries, dimensions of the Australian or any other standard may not be ergonomically suitable for people in other countries, where there are no ATM standards, e.g., in Saudi Arabia.

Workspace envelope is a three-dimensional space within which an individual works. When using an ATM, the user first inserts a card in the card slot by moving their hand, types the PIN on the keyboard, chooses a service and then takes the card back, possibly together with a slip, some banknotes or both. Usually, users do this while standing.

Accordingly, four of the most important dimensions that might have direct impact on the interaction between the user and the ATM are as follows:

- Screen height. The screen should be comfortably visible to the user and, therefore, close to their eye height. Very high screens with buttons will cause the arms and the head to be raised unnecessarily and might lead to fatigue in the neck, arms and the shoulders. Similarly, if the screen level is too low, the trunk and the neck will be inclined forward causing postural stress on the spine and its muscles. A moderate screen level will ideally not expose shoulders, arms or the back to excessive postural stress. In the present study, the height of the ATM screen is the distance between the floor and the middle of the screen. This height is compared to an optimum screen height estimated to be 300 mm below eye height of the 50th percentile of the user population. This high allowance was selected as it makes most ATM users look slightly downwards, which is preferred while working on computerized machines like ATMs and is considered more ergonomic than looking upwards [7].
- Keyboard height. Using keyboards may be considered as precision work. Grandjean recommended such precision work to be done 0–100 mm above elbow height [13]. The present study compares the height of ATM keyboards in Saudi Arabia to an optimum height. This optimum height (based on Grandjean's recommendation) is estimated to be 20 mm above the average (50th percentile) elbow height of the user population of ATM keyboards.
- Card slot height. Card slots must be visible to the user and easy to insert the card. Therefore, it is estimated that an optimum card slot height would be 100 mm above the average elbow

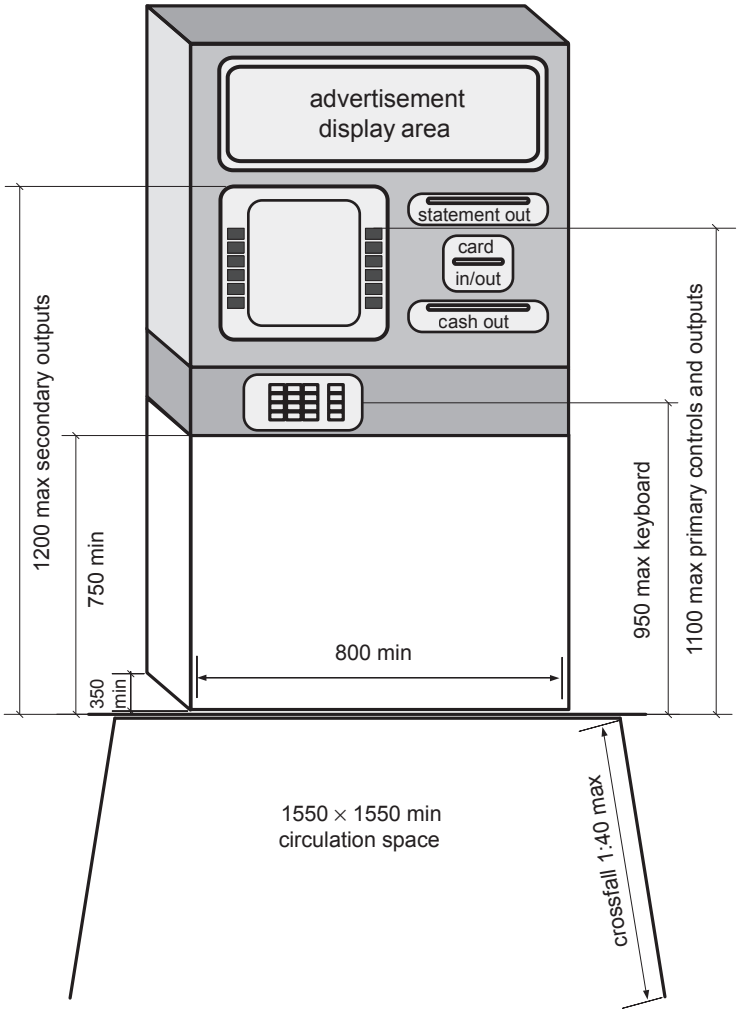

Figure 1. Automatic teller machine (ATM) dimensions recommended in the Australian standard [12].

height of adult user population (50th percentile). This study compares card slot height of ATMs in Saudi Arabia to optimum height.

- Cash slot height. Cash slots must be visible to the user and easy to reach. Therefore, it is estimated that an optimum cash slot height would be 50 mm above the average elbow height of adult user population (50th percentile). This study compares cash slot height of ATMs in Saudi Arabia to optimum height.

As Pheasant recommended using anthropometric data in designing machines [7] and the ATM user population usually does not include children, this study considered body dimensions of adults only. According to Coley et al., eye height and elbow height are the two body dimensions most critical in using an ATM [9].

A comprehensive field study was done to determine ATM types used in all 11 banks that operate in Saudi Arabia. Their dimensions were measured. Moreover, an extensive search of available anthropometric measurements of the Saudi population was done. Then, appropriate allowances for shoes were added. Finally, a set of most suitable ATM dimensions was recommended on the basis of a comparison between critical body dimensions and ATM dimensions.

The hypotheses to be tested for each of the four dimensions mentioned in this section, i.e., screen height, keyboard height, card slot height and cash slot height, were as follows:

$$H_0: \mu = \mu_0,$$
$$H_1: \mu \neq \mu_0,$$

where μ = average dimension (of all types of machines), μ_0 = recommended dimension (based on the anthropometric data of the user population).

To test H_0 for each dimension, a *t* test was done and a significance level of α = .05 was adopted.

In this study, the recommended dimension is based on the 50th percentile of the user population, i.e., design-for-average. Three principles are usual in workplace design with anthropometric measurements. The first principle is using the 5th or 95th percentiles, which represent the design-for-extreme principle (based on the criteria that almost all users should be accommodated). The awkward posture many ATM users adopt if ATMs are designed according to this principle makes this choice unfeasible. The second principle is design-for-adjustable-range, which is not practical and extremely costly. Accordingly, third principle, i.e., design-for-average, seemed best for ATMs [6, 7].

3. RESULTS AND DISCUSSION

The field study started with determining the types of ATM machines used by all banks in Saudi Arabia. At the time of data were collected, i.e., in the first half of 2009, six main types of ATM machines were used: NCR, NCR–M74, NCR–M76 (from NCR, USA), Abana–1200 XE (from Abana, Saudi Arabia), Diebold–720 and Diebold–520 (from Diebold, USA). For commercial reasons and to secure the anonymity of the manufacturing companies, these types were randomly coded ATM a to ATM f and were evaluated on an individual basis. Table 1 lists the measurements of the six types of ATMs.

Results in Table 1 clearly show that there were wide differences in dimensions between the ATMs used in Saudi Arabia. The maximum differences were 245, 295, 260 and 270 mm for the height of the screen, keyboard, card slot and cash money slot, respectively. This raises questions about the wisdom of having such a wide range of ATM dimensions and supports the need for standards in this area.

Three studies only discuss anthropometric measurements of the adult Saudi population [14, 15, 16]. According to those studies, the 50th percentile of eye height and elbow height of the adult population in Saudi Arabia, which are in turn the dimensions of the user population of ATMs, are 1577 and 1075 mm, respectively.

For shoe allowance, research studies usually give males 25 mm and females 45 mm [7]. Thus, an allowance for shoes of 35 mm was chosen for this study. Table 2 gives actual ATM dimensions based on the field study, recommended values based on the anthropometric measurements of the user population and *t* test results.

TABLE 1. Dimensions of Automatic Teller Machines (ATMs) Used in Saudi Arabia.

Dimension (mm)	ATM a	ATM b	ATM c	ATM d	ATM e	ATM f	*M*	*SD*
Screen height	1055	1300	1200	1300	1200	1250	1217	91
Keyboard height	805	1100	1000	800	1000	950	942	119
Card slot height	1075	1100	1100	1260	1100	1000	1106	85
Cash slot height	848	1000	900	1100	800	830	913	115

TABLE 2. Actual and Recommended Automatic Teller Machine (ATM) Dimensions

Dimension (Height)		Value (mm)			
ATM	Body	Anthropometric	Recommended	Actual Average	*p*
Screen	eye	1577	1312	1217	.03*
Keyboard	elbow	1075	1130	942	<.01*
Card slot	elbow	1075	1210	1106	.01*
Cash slot	elbow	1075	1160	913	<.01*

Notes. *$p < .05$; desired percentile: 50th.

There were significant differences between the four average existing ATM dimensions and the recommended ones with all actual dimensions being lower than the recommended ones (Table 2). This makes most users lean forwards while using ATMs, which puts an unnecessary load on the back, shoulders and arms and makes the whole process of using ATMs unpleasant.

4. CONCLUSIONS AND RECOMMENDATIONS

The results clearly show that there are wide differences in the dimensions of the different types of ATMs used in Saudi Arabia. Keeping in mind that there are no standard dimensions for ATMs in Saudi Arabia, these differences make the use and the degree of user-friendliness vary widely between ATMs.

Based on the results of previous anthropometric studies done on the Saudi population, a new set of dimensions for ATMs to be used in Saudi Arabia is recommended: screen height of 1337 mm, keyboard height of 1130 mm, card slot height of 1210 mm and cash slot height of 1160 mm.

It is concluded that the dimensions of the six types of ATMs used in Saudi Arabia do not match the recommended ATM dimensions based on anthropometric dimensions of the user population. In other words, there is a mismatch between existing and preferred dimensions of ATMs. It is suggested that banks take recommended dimensions into consideration before ATM purchasing decisions are made.

The limited scope of this study did not allow considering disabled or elderly ATM users. This study focused on healthy adult population. Designing special ATMs or finding other means to serve those two groups of users might be a way to address their needs; more research is necessary in this area.

Although outside the scope of this study, it was observed that there were no reliable and well-established anthropometric databases in Saudi Arabia as was the case in many Middle Eastern countries. More research is necessary in this field. This will help governments in formulating relevant standards and will also help designers and manufacturers in producing machines, like ATMs, that suit the user population.

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