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BEDRUNN3R: AN INTELLIGENT RUNNING ALARM CLOCK

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ABSTRACT

The conventional alarm clocks have been serving their purpose to mankind since their inception, to wake people up every single morning. However, the rates of oversleeping are still on the rise and people are having trouble waking up in the morning even with the use of alarm clocks. The snooze button that is available on all conventional alarm clocks provide user with more sleep but at a cost of deteriorating their quality of health and exacerbating sleep inertia at the same time. The objective of this paper is to study the problems associated with sleep that are often faced by people and to develop an intelligent moving alarm clock that implements the application of Artificial Intelligence. The Hypothetico-Deductive method will be used as the research methodology while the development will be following the Rapid Application Development (RAD) model. The developed prototype is tested against conventional alarm clocks and has shown significant improvements in the percentages of oversleeping and snoozing. Recommendations for continuation and future work of this paper are also included.

Keywords: artificial intelligence, intelligent, running, alarm, oversleeping, snoozing.

1. INTRODUCTION

Every living person on this globe share one common first thing that they all have to do every single day; waking up [1]. Even though it may sound simple, some people find it hard to wake up on time in the morning, especially for heavy sleepers. They oversleep and end up getting to work, classes or lectures late or even worse, missing out on important events in their life. Although alarm clocks have been developed to help combat this problem, they are still unable to stop people from oversleeping [2]. Therefore, one question exists; how can current engineering and technology assist to curb this problem? By applying my knowledge in Artificial Intelligence and robotics, I hope to be able to design an innovative and exciting way to develop a smart alarm clock as a solution to this situation.

2. PROBLEM STATEMENTS

There are two major problems that have been identified with the current sleeping habits of most people. Firstly, there is a problem of oversleeping which is a common problem which affects everyone. Conventional alarm clocks that are in the market now are not any more effective in forcing heavy sleepers out of bed and their effectiveness have dropped as they can often be turned off easily if they are within reach of the user. This problem is negatively impacting everyone as oversleeping reduces productivity of both workers and students alike because precious time is wasted on sleeping.

There is also a problem of sleep fragmentation that happens when the snooze button on alarm clocks is used excessively. The conventional alarm clocks in the market still allows users to press the snooze button for as much extra sleep as they want. Sleep fragmentation brings adverse effects to the human body such as hormonal imbalance, impaired daytime function, decreased reaction time, reduced short term memory, increased sleep inertia and increased blood pressure. Users who use the snooze button frequently often report of feeling tired and having decreased productivity at work and in school.

3. LITERATURE REVIEW

a) Oversleeping

Oversleeping refers to an intentional or unintentional act of sleeping beyond one's intended time for waking or intended time for getting up. Regardless of age, race, background and gender, everyone is subjected to the risk of oversleeping in the morning, especially if they do not have a proper sleeping pattern or do not have enough sleep regularly [1]. This statement is supported by a research [2], stating that in Japan, about half of the students in senior high schools are sleeping less than 6 hours during weekdays. Their sleeping pattern have been altered as a result of the habit of staying up late to do work and to study for tests. Another study [3] also shows that by not having a regular sleep pattern, students are subjected to higher risks of oversleeping in the morning. According to the results of the CDC's Youth Risk Behavior Survey in 2011 and 2013, high school students in the United States are not having a regular and ample amount of sleep, with 69% of the students sleeping less than 8 hours a day and 40% sleeping less than 6 hours. Another poll by National Sleep Foundation also recorded that 59% of 6th to 8th graders and 87% of U.S. high school students were getting less than the recommended 8.5 to 9.5 hours of sleep on weekdays [3].

b) Effects of oversleeping

Oversleeping may not seem to have a huge impact on the society, but researches done have proven otherwise. According to a research done in 2007 [4] in the United Kingdom, 28.1 million or 97% of the British workforce are not getting enough sleep at night during

workdays and has subsequently, affected their ability to wake up on time to work in the morning. On average, 49% of the British workers clock in to work late every day and 20% of these workers do so due to having overslept.

The National Institute of Health claims that those who oversleep more will tend to rely more heavily on alarm clocks. They are also the ones who tend to use the snooze button excessively in order to get every little amount of extra sleep that they can get before starting the day. This raises another health concern as excessive snoozing will subsequently lead to fragmented sleep or sleep fragmentation [5].

c) Sleep fragmentation and sleep cycle

According to Sleepnet [6], sleep fragmentation can be defined as the interruption of the sleep stage as a result of the appearance of a lighter sleep stage or due to waking up. In its natural state, sleep can be divided into 5 stages, which is stage 1, 2, 3, 4 and Rapid Eye Movement (REM) sleep. Stages 1 to 4 are grouped under Non-Rapid Eye Movement (NREM) sleep and stages 3 and 4 are referred to as deep sleep. These sleep stages progress cyclically from 1 through REM then restart again with stage 1. A complete sleep cycle takes an average of 1.5 hours to 2 hours. It is important that the natural sleep cycles are not interrupted as some stages prepares the body for sleep while some prepares it for waking up. Waking up from a deeper stage of sleep will leave a person feeling refreshed while waking up from earlier stages of sleep will leave the person feeling groggy and tired. This happens because interrupted or fragmented sleep causes the sleep cycle to immediately stop and if the person goes back to sleep after, the sleep cycle does not continue from where it left off, but rather the cycle restarts at an earlier stage. Thus, instead of waking up from a deeper stage of sleep which prepares the body to wake up, the person is woken up from earlier stages of sleep which does the complete opposite, making it worse for the person [6].

d) Effects of sleep fragmentation

A recent study [7] claim that excessive sleep fragmentation can lead to various health concerns. Among the clinical effects of sleep fragmentation include increased objective sleepiness, decreased mental performance, decreased reaction time, decreased alertness, hormonal effects, pulmonary effects, and many more. The findings of another research [8] also found that subjects of fragmented sleep experienced increases in blood pressure up to a degree of 75 percent. It showed that fragmented sleep have a less restorative effect compared to interrupted sleep and instead of making a person feel better, it does the complete opposite and proves that sleep fragmentation causes a higher degree of sleepiness and daytime-function impairment after waking up [7, 9].

e) Artificial intelligence

According to Jones [10], Artificial Intelligence or more commonly known as AI, is the field of study where computers or computer-based systems are taught or made to replicate intelligence found in human beings. The main focus of Artificial Intelligence is to create or develop computers which can perform tasks commonly associated with intelligent beings [11]. The field of AI can be broken down into separate research groups, such as machine learning, natural language processing (NLP), expert system, fuzzy logic, computational biology and many others [10].

f) Existing moving alarm clocks

Figure-1. Clocky and tocky (Nanda home, 2008).

Clocky is a moving alarm clock that was created by Nanda Home. It moves by rolling on its two wheels that are located at the side of its body. Meanwhile, Tocky, the elder brother of Clocky, does not have any wheels but moves by rolling using its body as a ball. Both Clocky and Tocky are activated once the user presses the snooze button for the second time and move by using a random algorithm to determine its direction of movement. While it is moving, Clocky uses sensors to locate small obstacles in its path and to then avoid them but Tocky does not. Clocky and Tocky move randomly around the room while sounding the alarm and forces the user to find them to turn off the alarm.

Figure-2. Puzzle alarm clock (Perpetual kids, 2015).

The Puzzle Alarm Clock, developed by Perpetual Kids does not move but rather, uses movement to fire out three puzzle pieces of different shapes and sizes. At the time of the alarm, the alarm clock sounds the alarm and immediately shoots out the puzzle pieces, scattering them all around the alarm clock randomly. To turn off the alarm, the user has to find all three puzzle pieces and fit them back into their slots on the alarm clock. The disadvantages of this alarm clock is that the user will get used to it after some time and the puzzle pieces are very easy to find.

Figure-3. Rocket launcher alarm clock (Perpetual kids, 2015).

The Rocket Launcher Alarm Clock, also developed by Perpetual Kids is another movement-based alarm clock that fires out a part of the alarm clock at the time of the alarm. The range of this alarm clock is about 1.5 meters and in a 30 degree angle in the direction of the alarm clock. To turn off the alarm, the user will have to find the rocket and fit it back to its port. The disadvantages of this alarm clock is that the location of the rocket is very predictable and can be easily found by the user as the distance is very short.

Figure-4. Flying alarm clock (Tech tools, 2015).

The Flying Alarm Clock is equipped with a detachable propeller that is developed by Tech Tools. It operates almost similarly to the Rocket Launcher Alarm Clock, but it has a higher range and is more unpredictable. At the moment the alarm is sounded, the propeller lifts off and flies randomly high up and lands in a random location around the room. The user will be forced to look for a small propeller in the room in order to put it back in place. The disadvantage of this alarm clock is that it is very easy to lose the propeller.

The comparative study has been summarized on the next page. The proposed BEDRUNN3R would contain artificial intelligence, which is not present in any other alarm clocks in the market currently. It will follow a rule-based algorithm which enables it to move autonomously within the room, while minimizing time taken to achieve its goal, which is to hide or run. BEDRUNN3R will also be equipped with the ability to locate hiding spots and to hide itself from the user, making it hard to be found or turned off, a new feature that has yet to be implemented in any moving alarm clocks. It can also utilize its infrared sensor to sense for the user's presence, running away whenever they come too close. To further optimize its performance, BEDRUNN3R is well programmed with an obstacle avoidance algorithm, enabling it to move away from small obstacles that might block its path. Although the cost of BEDRUNN3R is higher, it is only for the prototype that serves as a proof of concept. Once the concept is proven, BEDRUNN3R can be mass produced using Arduino, which will only cost a small fraction of the original cost and at the smaller, sturdier size.

No.	Existing Alarm Clock	Advantages	Disadvantages	Intelligence	Snoozing Prevention	Obstacle Avoidance Ability	User Detection Ability	Hiding Ability	Customizability	Dimensions
1	Clocky (Nanda Home, 2008)	• Simple design • Small	• Fragile • Only able to move randomly • Volume is not adjustable • Might turn off accidentally	Yes, but very limited.	No	Yes	No	No	No	14cm x 9cm
2	Tocky (Nanda Home, 2008)	• Simple design • Small • Able to sustain fall • Able to store and play various music	• Bad user interface • Only able to move randomly • Hard to replace battery • Might turn off accidentally	No	No	No	No	No	No	9cm x 9cm
3	Puzzle Alarm Clock (Perpetual Kids, 2015)	• Forces user to think to solve the puzzle • Low cost	• Short distance • Easy to solve • User gets used to it after some time	No	Yes	No	No	No	No	13cm x 5cm
4	Rocket Launcher Alarm Clock (Perpetual Kids, 2015)	• Can only be turned off by finding the rocket • Low cost	• Short distance • Predictable	No	Yes	No	No	No	No	7cm x 7cm
5	Flying Alarm Clock (Tech Tools, 2015)	• Cool design • Unpredictable • Low cost	• Short distance • The propeller may get lost above or behind furniture • Can be turned off without finding the propeller	No	Yes	No	No	No	No	7cm x 7cm
6	BEDRUNN3R	• Has AI • Follows a rule-based algorithm • Able to look for objects to hide • Able to detect user and obstacles • Can be customized	• Higher cost (for prototype) • Bigger size (for prototype) • Limited choice of music • Battery must be charged daily (for prototype)	Yes	Yes	Yes	Yes	Yes	Yes	9cm x 6cm

4. METHODOLOGY

a) Research methodology

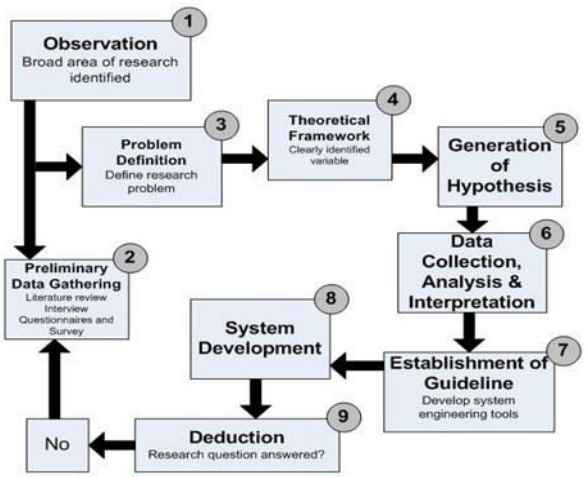

Figure-5. Hypothetico-deductive methodology.

The Hypothetico-Deductive Method was used throughout this research. Under this deductive method, observation and data gathering is first done to identify or define an existing problem within an area of research. A hypothesis is then formulated through scientific inquiry in a form that could possibly be falsified by a test on observable data. For this paper, the hypothesis formulated is "If artificial intelligence is implemented into moving alarm clocks, it will reduce the percentage of oversleeping, snoozing and time taken to turn off the alarm". Next, falsification takes place, in which a test that could possibly prove the hypothesis wrong is carried out. A test that could but does not run contrary to the hypothesis validates the theory. It is then proposed to compare the explanatory value of competing hypotheses by testing how strictly they are verified by their predictions. If the objectives and hypothesis are not met, the work need to go back to the early phases and the process is started all over again.

b) Development methodology

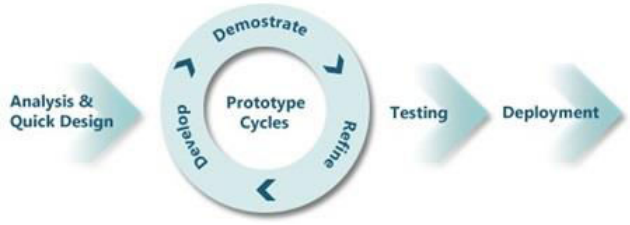

Figure-6. Rapid application development model.

The development of this research requires the integration of hardware and software. The development stage goes through quick, successive cycles of prototyping as in Rapid Application Development (RAD).

The primary focus in RAD is the speed in which prototypes are developed. As more prototypes go through a series of refinement and development, bugs and errors can be removed and potential flaws can be removed before the final product is produced. RAD model suits this research as the research objectives are well-defined and understood and the technical architecture is clear. The main phases in RAD are analysis and quick design, prototyping cycle, testing and deployment.

c) System modeling

1) System flow

The flow of the entire system is divided into 2 parts,

- Hiding Mode - The default mode, where the robot looks for a low object to hide under.
- Running Mode - The mode that is only activated upon failure to hide during Hiding Mode, and uses infrared sensors to detect the presence of user before running away from him.

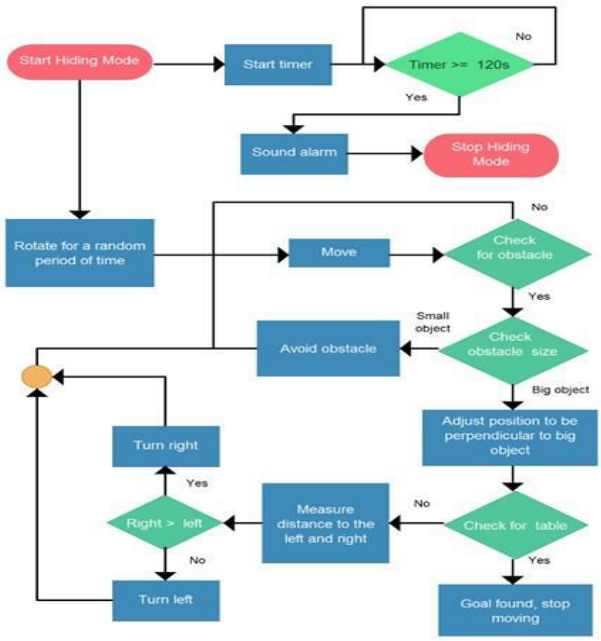

Figure-7. Hiding mode flowchart.

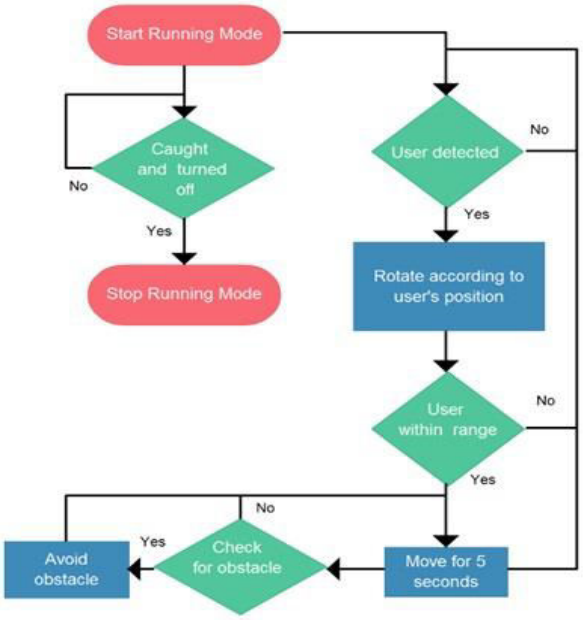

Figure-8. Running mode flowchart.

2) Hardware configuration

The hardware configuration and the port details for the prototype, BEDRUNN3R is shown and described below.

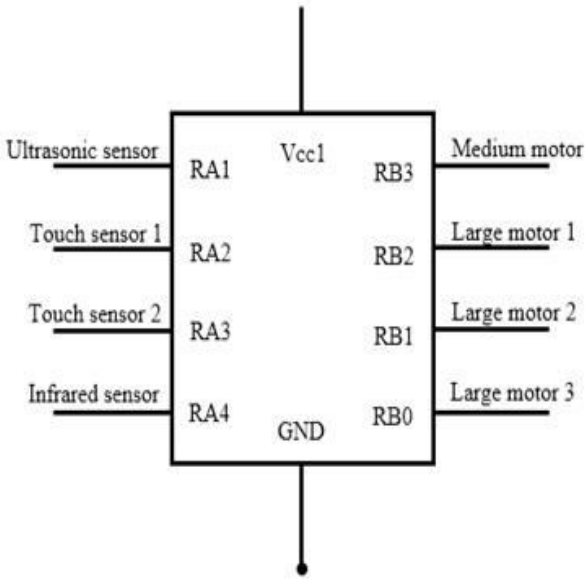

Figure-9. PIC chip diagram for BEDRUNN3R.

Table-1. Description of ports used.

Port	Input/Output	Description
RA1	Ultrasonic sensor	Detects proximity of the robot to other objects
RA2	Touch sensor 1	Detects obstacles and allows for positioning of robot to be perpendicular to a wall
RA3	Touch sensor 2	Detects obstacles and allows for positioning of robot to be perpendicular to a wall
RA4	Infrared sensor	Detects proximity to the user with infrared beacon and allows the robot to change its direction depending on the direction of the user
RB3	Medium motor	Rotates the ultrasonic sensor so look in different directions
RB2	Large motor 1	Moves and rotates the robot depending on the current objective
RB1	Large motor 2	Moves and rotates the robot depending on the current objective
RB0	Large motor 3	Rotates the medium motor until the ultrasonic faces upwards to identify low objects

3) Tools used

The main tool used for this research is the LEGO Mindstorms EV3. It provides a platform for development for robotics and enables users to build a robot from scratch using various building parts that are in the Core Set, Expansion Kit and also Development Kit. The main components used for BEDRUNN3R is shown in the table.

Table-2. List of components used.

Component	Description
LEGO Mindstorms EV3 Brick 	The brain of the robot that controls all other components such as sensors and motors. The program is uploaded into the brick via Bluetooth or USB cable and can be run directly from the brick.
Large Motor 	Enables rotation and movement of wheels. BEDRUNN3R uses 3 of this motor for movement and for rotation of the ultrasonic sensor.
Medium Motor 	Enables rotation of parts connected to it. BEDRUNN3R uses this to rotate the ultrasonic sensor in a 360° manner.
Ultrasonic Sensor 	Used to distinguish between small and big objects, identify low objects and determine furthest distance to move.
Infrared Sensor 	Used to detect for the presence of user that is equipped with an infrared beacon. Also used to identify which direction the user is coming from and to position the robot in the opposite direction.
Touch Sensor 	Used to detect small obstacles that cannot be detected by the ultrasonic sensor. Also used to position the robot perpendicular to a wall.

d) Evaluation methodology

After the prototype has been developed, it is tested in order to determine if it meets specified requirements and fulfils its intended functionalities. The testing will be done in stages using the V-Model. The first stage will be unit testing. Then, the second stage, integration testing takes place. The testing then proceeds with the third stage, system testing, in which the entire system flow is tested in a test environment, which simulates the actual bedroom environment. The test environment is strictly designed to meet the scope of the research such as in terms of dimension and obstacles used. Once it passes the system testing, the final stage of testing or the acceptance test is carried out. Acceptance testing tests the prototype in the actual environment and in this case, an actual student bedroom with actual obstacles. The prototype's performance will be evaluated and the effectiveness will be tested against conventional alarm clocks.

5. RESULTS AND DISCUSSION

a) Observation

Observation was done on student bedrooms within Universiti Teknologi PETRONAS (UTP) and Multimedia University (MMU). The rooms that were observed were from different residential areas and include both male and female bedrooms. Among the main points of focus are the size of the room, arrangement of tables, chairs, beds, wardrobes, type of material used for the floor and also common small objects found in the bedroom.

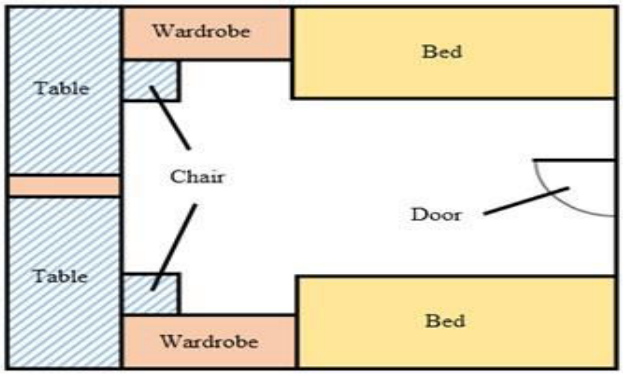

Figure-10. Observed architecture of student room.

Table-3. Common features of room architectures.

Item	Observed Features
Room architecture	Square or rectangular, with sharp 90° corners.
Size and dimension	5m x 5m, 7m x 6m.
Table	Located along the walls in the room, and beside large objects such as wardrobes and beds.
Floor material	Cement, tile or carpet.
Obstacles	Shoes, cups, bottles and small tins.

b) Prototype design

Through the Rapid Application Development (RAD) model, several prototypes of BEDRUNN3R have been developed. After every stage of prototyping, the prototype is enhanced and improved in order to fulfill its requirements in the most efficient and effective way.

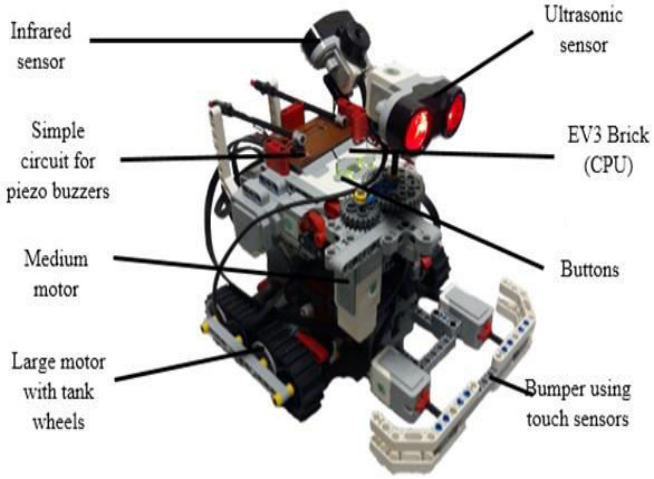

Figure-11. Latest prototype of BEDRUNN3R.

c) Surface movement test

Surface Movement Test is carried out to test the movement of the prototype on different surfaces which are commonly found in student rooms.

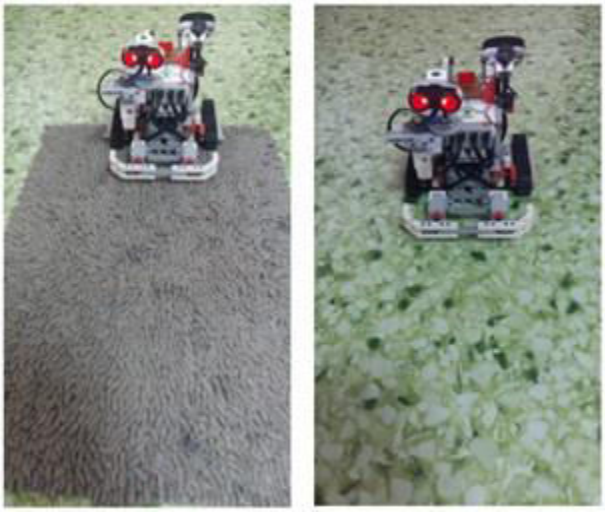

Figure-12. Surface movement test.

Table-4. Results of surface movement test.

Surface	Distance (m)	Time (s)	Speed (m/s)	Able to Move
Rough	1	3.3	0.303	Yes
Smooth	1	3.1	0.323	Yes

The results of this test show that BEDRUNN3R is able to move smoothly on both rough and smooth surfaces. However, the speed differs by a small margin of 0.02 seconds.

d) Hiding test

Table-5. Results of hiding test.

Result	Successful	Not Successful
Number of Test Cases	22	8
Percentage (%)	73.3	26.7

From the results, it can be seen that BEDRUNN3R has managed to hide itself in 22 out of 30 test cases. This translates to a 73.3% success rate of finding a hiding place in room before the alarm is sounded. This would mean that the user would have to search for the alarm clock out of all possible spots in the room. For the cases in which it does not manage to hide, the Running Mode will be triggered.

e) User acceptance test

The User Acceptance Test (UAT) was conducted starting from the 25th of June 2015. This testing was carried out in the actual bedroom environments of 4 respondent groups consisting of all heavy sleepers from different genders and age groups. By having these different groups, it helps to diversify the results obtained in order to get a more accurate result that is more applicable to the real world. The details of the respondent groups for the test are shown in the table below.

Table-6. Details of respondent groups.

Respondent Groups	Gender	Age Group
A	Male	Before Internship
B	Male	After Internship
C	Female	Before Internship
D	Female	After Internship

The test was conducted using BEDRUNN3R and also conventional alarm clocks, to test for their effectiveness. Once the respondents have been woken up by the alarm, they would have to record the time taken to turn off the alarm and whether they chose to snooze the alarm or go back to sleep. The results of this test will be shown and discussed below.

Table-7. Test results using BEDRUNN3R.

Group	Test Case	Alarm Snoozed		Waking Time		Time Taken to Turn Alarm Off (s)
		Yes	No	On Time	Overslept	
A	1		✓	✓		41
	2		✓	✓		37
	3		✓	✓		58
B	1		✓	✓		43
	2		✓	✓		45
	3		✓		✓	51
C	1		✓	✓		58
	2	✓			✓	34
	3		✓	✓		39
D	1		✓	✓		55
	2		✓	✓		29
	3		✓	✓		45

Table-8. Test results using conventional alarm clocks.

Group	Test Case	Alarm Snoozed		Waking Time		Time Taken to Turn Alarm Off (s)
		Yes	No	On Time	Overslept	
A	1		✓		✓	8
	2	✓			✓	5
	3		✓	✓		5
B	1	✓			✓	9
	2	✓			✓	7
	3	✓			✓	14
C	1	✓			✓	5
	2	✓			✓	6
	3		✓		✓	8
D	1		✓	✓		12
	2	✓			✓	9
	3	✓			✓	6

The results obtained are further analyzed into the tables below.

Table-9. Analyzed results of conventional alarm and BEDRUNN3R.

Type of Alarm	% of Snoozing	% of Oversleeping	Average Time Taken to Turn Alarm Off (s)
Conventional	66.67	83.33	7.83
BEDRUNN3R	8.33	16.67	44.58

From the table above, we can see that the percentage of snoozing using BEDRUNN3R has been greatly reduced by 58.34%, from 66.67% to 8.33% of conventional alarm clocks and BEDRUNN3R respectively. The percentage of oversleeping has also been reduced from 83.33% to a mere 16.67%, indicating a successful reduction of 66.66%. For the average time taken to turn alarm off, BEDRUNN3R has proven successful in making it hard for the users to turn it off, with an average time of 44.58 seconds as compared to the conventional alarm clock with a 7.83 seconds.

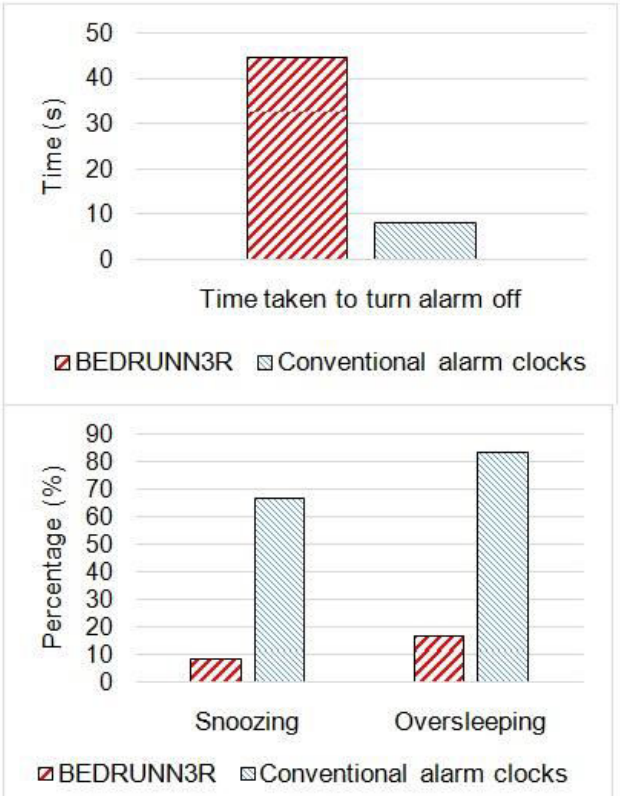

Figure-13. Comparison between results of BEDRUNN3R and conventional alarm clocks.

This result shows that by forcing users to spend a longer time in turning off the alarm clock, the users will have to move around more, increasing their level of alertness. The users are also forced to think of the possible hiding spots where BEDRUNN3R could be hiding, and this combined with the increased movement could possibly contribute to the increased awareness and reduced sleepiness. Thus, users have a lesser tendency to go back to sleep which would lead to oversleeping, and they are less likely to snooze their alarm clock. Thus, BEDRUNN3R has successfully exhibited that the application of Artificial Intelligence in alarm clocks will increase its effectiveness in serving its purpose.

6. RECOMMENDATIONS

In the future, I would recommend for the real product to be developed using Arduino, while following the same hardware and software configurations that have been identified and developed in this paper. The parts and sensors for Arduino are cheaper and cost lesser to be developed in a large scale. Arduino will also allow the size of the alarm clock to be smaller and at the same time,

weights lesser in comparison to LEGO.

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