Journal of Engineering, Mechanics and Modern Architecture
Vol. 3, No. 06, 2024 ISSN: 2181-4384

Innova Science

INTELLIGENT CONTROL DESIGN TO CONTROL THE TRACKING OF THE MOVING ROBOT

Abstract:

In this research, the Sequential Pattern Analysis (SPA) method was used to create patterns in the movement of robots according to their movements during a certain period of time in the past and also according to the time of occurrence of these movements. SPA extracts data related to the movements of 15 robots, collected by accelerometer sensors embedded in the body of the robot, and stored in a dataset in the UCI standard data repository. Then, by examining the movements of the robot in the training data set, the regular patterns that are repeated more than a threshold value among the training data and are unique for each robot, specifies Then these patterns are used to predict the movements of the robot in the next period of time and among the test data set , The results of the tests show that the accuracy of the proposed method in predicting the next movements of the robot reaches 99.39%, which is a high accuracy value and is improved by 0.21% compared to the best previous method available in the publications.

Keywords: *intelligent control, path tracking control, mobile robot.*

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1-Introduction

Currently, the use of robots to perform tedious tasks or hard work in furnaces, refineries and industrial centers is growing rapidly. The accuracy of operations related to tracking movements or path navigation by robots is very necessary in many cases. One of the most important challenges in using robots is to accurately identify the movements, movements performed by the robot and predict the movement or next movements of the robot. In this research, we will propose a method for intelligent control of movements and tracking of the robot's movement path. The generalities of the research are given in this chapter.

2-1- Statement of the problem

Ground robots fall into two categories: stationary robots and mobile robots. Static machines are robots whose base is fixed in a certain place and therefore their working areas are limited due to their kinematic structure and the dimensions of their connections. Unlike stationary robots, mobile robots are robots that can move independently from one place to another, that is, they have the ability to move freely within a designated area to perform specified tasks and achieve goals[1]. Autonomous mobile machines (AMR) can navigate unpredictable environments, listen to natural language, recognize objects, find their location, plan routes, move independently, and generally think for themselves. AMR design uses smart, intelligent and behavior-based control and technology methods and tries to optimize performance with minimum input and minimum computation [2].

3-1-Research objectives

- *Increasing the accuracy of tracking the path of the robot*
- *Increasing the accuracy of predicting the next movement of the robot*

4-1-Research hypotheses

- *According to mobile robot applications, tracking the path of the robot is very important.*
- *Tracking the path of the robot, patterns can be designed to predict the next movements of the robot.*
- *Patterns predicting the path of the robot are obtained from the actual movement and the estimated movement of the robot.*

5-1- The main question

- *How to accurately track or predict the moving path of a moving robot?*

1-2-Introduction

Currently, mobile robots currently have a variety of applications in various fields of human life. These robots can be used to perform repetitive or dangerous tasks. There are various challenges in using these robots. One of these challenges is tracking the movement of the moving robot. In this research, we propose a method to intelligently control the movement of these moving robots. In this chapter, we will provide explanations about artificial intelligence, pattern discovery methods, and mobile robots, and in the following, we will review the background of research conducted by various researchers related to this thesis.

2-2-Artificial intelligence

Artificial intelligence has many definitions based on the nature of the techniques, its use and also the timeline of its research. However, the most common definition is as follows [3]:

- *Artificial intelligence is the intelligence and ability shown by a computer to understand, learn and solve problems with minimal probability of failure.*
- *One of the most popular research fields of artificial intelligence is intelligent agents. That is, any device that understands its environment and takes actions that maximize its chances of success in some goals.*
- *Today, most of the artificial intelligence systems being developed are usually specialized systems that use a knowledge database to make decisions.*

1-2-2-Advantages of using artificial intelligence

Some of the advantages of using artificial intelligence are [3]:

- *Humans often make mistakes, but in artificial intelligence, machines make decisions based on previously stored data. Deductive algorithms the possibility of errors and mistakes. In this process, the most complex and important issues are solved very quickly and without the slightest mistake, and it becomes a great success.*
- *artificial intelligence and robotics are used in the extraction and processes related to the exploration of fossil fuels.*
- *GPS helps us to find any address around the world easily. These days, like food, clothing, and shelter, smart phones are part of human needs , Artificial intelligence is directly used by financial institutions and banking because it helps organize and manage data. It also uses artificial intelligence to detect fraud.*

2-2-2- Disadvantages of using artificial intelligence

Some of the disadvantages of artificial intelligence are [4]:

- *Using artificial intelligence costs a lot. But anyway, everything has a price. Since such machines are complex, you usually have to pay a lot of money for them.*
- *Artificial intelligence is not a substitute for humans. It doesn't matter how smart the machine is, it can't replace humans anyway. No matter how logical and intelligent a machine is, it is still not a human being, because it does not have emotions or excitement, nor does it have any human values. Machines don't know anything about ethics and they don't know the law, so they don't have the power to judge and they can't be judged.*
- *Devices equipped with artificial intelligence do not improve with experience. Artificial intelligence, unlike humans, does not improve by experience. If the machines are not given a new program, they will do the same repetitive and usual tasks. On the other hand, cars depreciate over time.*
- *Intensive use of technology has greatly reduced the number of people needed for some jobs. In the future, if machines can perform all human tasks, training human skills will become useless and we will see massive unemployment among humans worldwide.*

3-2-2-Applications of artificial intelligence

Artificial intelligence has wide applications in all areas of human life. In this section, we explain some of these applications:

1-3-2-2-Medical applications

Artificial intelligence services have brought services and value to medical science. Doctors identify patients and their problems with the help of machines equipped with artificial intelligence. Some apps provide education to help inform about the side effects of medications. Doctors are trained in therapeutic surgeries with artificial intelligence simulations. Artificial intelligence is used for the diagnosis and immunity of nerves and the movement of brain functions. Artificial intelligence is also used in radiosurgery (surgery with radio rays). In this type of surgery, without damaging the healthy tissues, tumors or desired areas are operated on or removed from the patient's body [5].

2-3-2-2-Creating accurate and fast decisions in different departments

The complete absence of emotions and emotions in machines increases their efficiency, because with this featureThey can make good and correct decisions in the shortest possible time. The best example of this feature is in the health system. The use of artificial intelligence tools in different parts of the health system greatly increase the efficiency of treatment, because the use of artificial intelligence will greatly reduce the possibility of wrong diagnoses[6].

4-2-2-branches of artificial intelligence

Artificial intelligence is a very broad and complex science with many implications; The branches of artificial intelligence are [5]: (Experts Systems)

- *Robots*
- *Machine learning*
- *Neural networks*
- *Fuzzy logic*
- *Natural language processing*

2-4-Robots

Robots are often modeled on humans, if not in form, at least in function. Nature provides a remarkable model for robot builders to emulate. It is our duty to get ideas. Some mechanisms found in nature can be copied in the robotics workshop and classroom. Robots can be made with eyes to see, ears to hear, mouth to speak[7].

1-1-4-2-immobile robots

In fact, the most common robots are non-mobile types of robots that are fixed in place and do not move. These robots are often used in production and are connected to the ground. These stationary robots, such as the one in Figure 2-3, help build cars, appliances, and even other robots.[8]

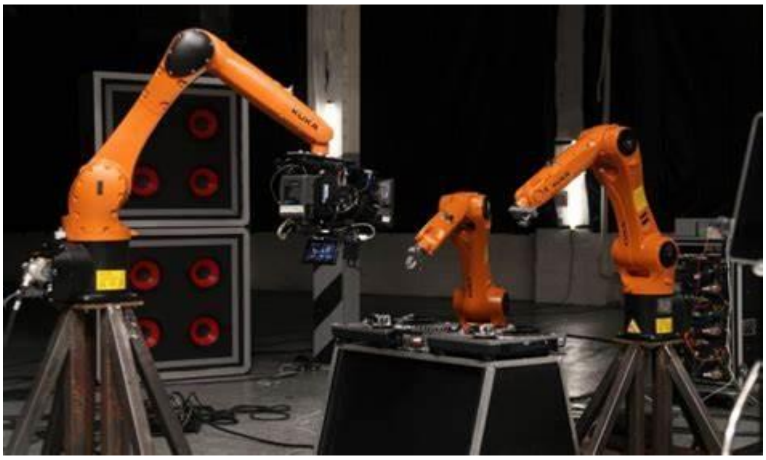

Figure 2-3- An example of fixed robots

2-1-4-2-mobile robots

Likewise, some of the most important challenges in designing mobile robots are:

maneuverability, adequate power supply, and collision avoidance.

An example of mobile robots is shown in Figure 2-4. These robots are designed to move from one place to another. Wheels, chains, or legs allow the robot to traverse a terrain. Mobile robots may also have an arm-like part that allows them to move objects around them. Of the two fixed or mobile robots – the mobile robot is probably the more popular hobby project.

Figure 2-4- An example of mobile robots [17]

2-4-2-Advantages of robots

Some of the advantages of robots are [7]:

- ***Security***

Safety is a clear advantage of using robots. Heavy machinery, hot machines and sharp objects can easily injure a person. When you delegate dangerous tasks to robots, you're more likely to be hit with a repair bill rather than a serious medical bill or lawsuit. Workers doing simple tasks will realize that robots can eliminate some risks.

- ***Speed***

Machines do not stop and do not need to rest. They don't want vacation time and they don't want to leave early. The machine may not feel stress and start working slowly. They also do not need to be invited to staff meetings or training. The machines can operate at any time of the day, increasing production speed. They don't force your employees to work harder to meet fast deadlines or seemingly impossible standards.

- ***Compatibility***

Machines don't have to worry about their thoughts during many things. Their work doesn't depend on the work of others. They won't face sudden emergencies and won't have to move around to do serious work. They're always there and doing what they're supposed to do. Automation is more reliable than human labor.

- ***Increasing the quality of services***

Bots always deliver quality. Since they are programmed for precise and repetitive movement, they make less mistakes. In some ways, robots are both employees and a quality control system. The absence of quirks, combined with the elimination of human error, creates a completely predictable product every time.

- ***Happier employees***

Your employees will be very happy with them, as robots are often chosen to perform tasks that humans do not enjoy, such as heavy work, frequent movements, or dangerous tasks. They will focus on many interesting activities in which it will be impossible to find their muscles. They may want to take advantage of additional training opportunities, take advantage of your employer's program, or participate in a special business project. They like to let bots do whatever it takes to get them burned.

- ***Creating jobs***

Machines don't destroy jobs. They only replace normal functions. Machines need people to supervise and control them. The more robots we need, the more people we need to build them. By training your employees to work with robots, you give them a reason to be motivated in their positions at your company. They will be there to thrive and have a unique opportunity to develop a new level of technology or related skills.

- ***Increase Productivity***

Machines can't do everything. Some jobs really need to be done by someone. When your human employees aren't busy with tasks that can easily be left to robots, they'll be approachable and helpful. They may communicate with customers, respond to emails and social media posts, assist with marketing and sales, and sell products. You won't be surprised at how much they can accomplish when the workload isn't overwhelming.

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1-3-Introduction

The text explores the importance of maneuverability for mobile robots, such as unmanned vehicles, aerial vehicles, and ships, in navigating through environments while avoiding obstacles. To develop a robust robot guidance system, researchers designed an intelligent controller based on the dynamic time deviation (DTW3) algorithm. This algorithm analyzes the previous movement patterns of the robot to predict its future path accurately. The method combines sequential pattern exploration with the dynamic time deviation algorithm to enhance the accuracy of path tracking. By comparing predicted and actual movements, the algorithm aims to improve the robot's path prediction. The chapter elaborates on the dynamic time deviation algorithm, sequential pattern exploration, and the proposed method for enhancing robot guidance systems.

2-3- Dynamic time deviation (DTW)

Dynamic time warping is a well-known technique for finding the optimal trade-off between two (time-dependent) series under certain constraints (Figure 3-1). Directly, the series are related non-linearly. Basically, DTW has been used to compare different speech patterns in automatic speech recognition. In fields such as data mining and information retrieval, DTW has been successfully used to automatically deal with time variations and different speeds associated with time-dependent data [1].

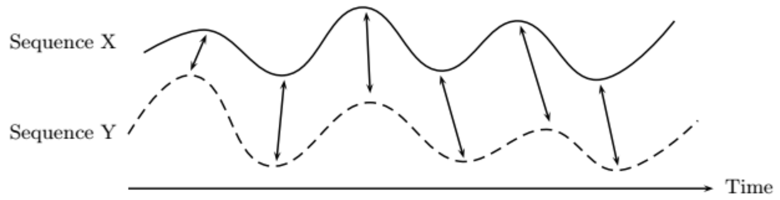


Figure 1-3- Time balance of two time-dependent series [1]

3-3- Exploration of sequential patterns

Sequential pattern exploration is the process of discovering frequently occurring sequences of transactions in a database. A sequential database stores records that occur in sequence, either chronologically or without regard to time. Examples include robot trajectories, customer transactions, DNA sequences, and blog data.

Sequential pattern exploration is an important problem in machine learning with many applications, such as motion path discovery, customer purchase analysis, and API usage exploration.

Existing algorithms for sequential pattern exploration can be categorized into two main approaches: Apriori-based methods and pattern growth algorithms. Apriori-based methods rely on the Apriori property to generate and test candidate patterns, but have high computational costs. Pattern growth algorithms instead recursively map the database to smaller subdatabases based on current patterns, avoiding candidate generation and pruning steps.

- *A sequential database D is given, with a minimum support threshold of 2.*
- *The set of items in the database is {a, b, c, d, e, f, g}.*
- *The sequence ‹a(abc)(ac)d(cf)› has 5 sets of items: (a), (abc), (ac), (d), and (cf).*
- *Item a appears 3 times in the sequence, while items a and c appear most frequently among the different items.*
- *The entire sequence ‹a(abc)(ac)d(cf)› only contributes to the support count of item a once.*
- *The sequence ‹a(bc)df› is a subsequence of ‹a(abc)(ac)d(cf)›.*
- *Since the sequences with IDs 1 and 3 both contain the subsequence ‹(ab)c›, this is a sequence pattern of length 3 (a 3-pattern).*

Table 3-1- A sequential database [3]

Sequence_id	Sequence
1	‹a(abc)(ac)d(cf)›
2	‹(ad)c(bc)(ae)›
3	‹(ef)(ab)(df)cb›
4	‹eg(af)cbc›

4-3-Proposed method

As mentioned, technological systems are increasingly used to monitor physical activities and overall evaluation and monitoring of the behavior and performance of robots, specifically by installing small sensors and computing devices to the robot, in order to Obtaining the performance of the process or predicting the movement path have become important. Pervasive computing technologies are applied to robotic systems, which provide feedback information on the quality of movements performed by the robot. In addition, the information obtained may be used in order to adapt the equipment to the current needs of the robot. Due to the rapid progress in hardware capabilities and the potential of data processing methods, it is expected that the emphasis of future developments will be on the development of intelligent systems that can not only analyze data, but also strategies and estimations. Show what is necessary in the path of the robot.

1-4- Simulation tool

In this research, MATLAB simulation software has been used to implement the prediction model of robot movements. MATLAB1 is a high-level language with an attractive environment, which was originally developed based on the C programming language. The word MATLAB means both the digital computing environment and the corresponding programming language itself. The name refers to the matrix-oriented approach of the program, where even single numbers are treated as matrices.

2-4- Implementation of the proposed method

To implement the proposed method, motion data of 15 robots were extracted from an activity detection dataset using an accelerometer built into the robot body stored in a machine learning data warehouse (UCI). These movements are divided into seven categories, and are recorded by sensors in the robot's body. The data from these sensors forms a specific pattern for each of the following seven activities:

1. Sitting

2. Getting up, walking, going up and down the stairs

3. Stand up after moving

4. Walking after stopping

5. Going up and down the stairs

6. Deviation to the right while walking

7. Deviation to the left while walking

The spatial data for each activity is divided into training data and test data. These data are the coordinates of the robot's location points relative to the origin of the coordinates, where the change in the robot's position is calculated at moment tn compared to moment tn-1 in the x, y, z axes. This variation is used in pattern matching and identifying recurring sequential patterns. The displacement changes between movements of the training data set are shown in Figure 4-1.

[1] MATLAB

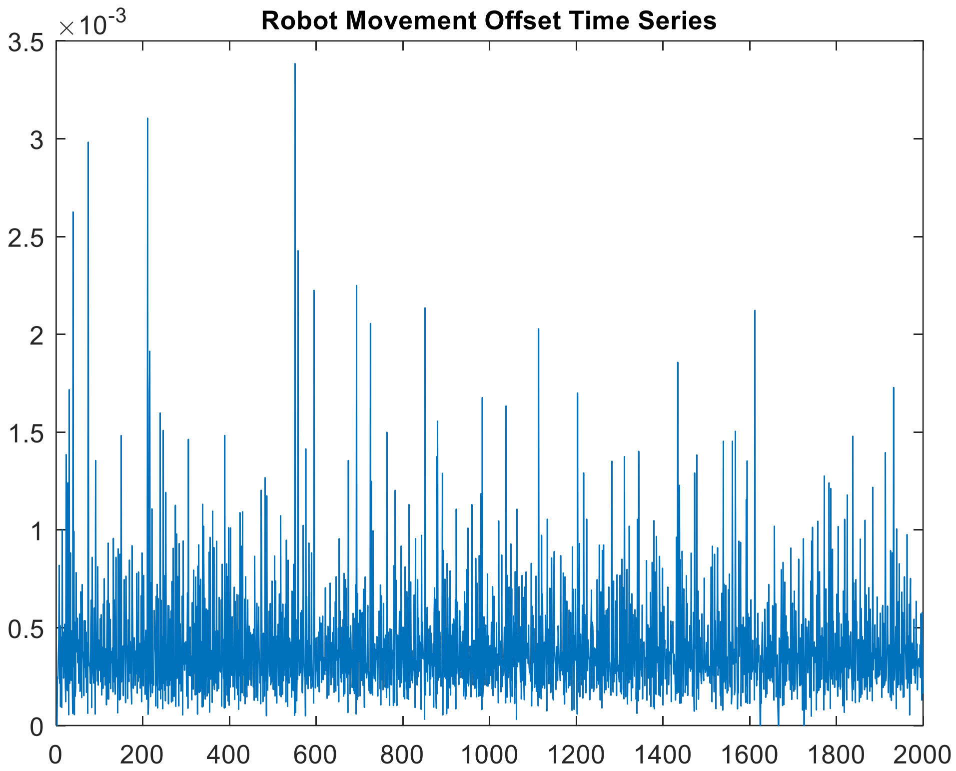
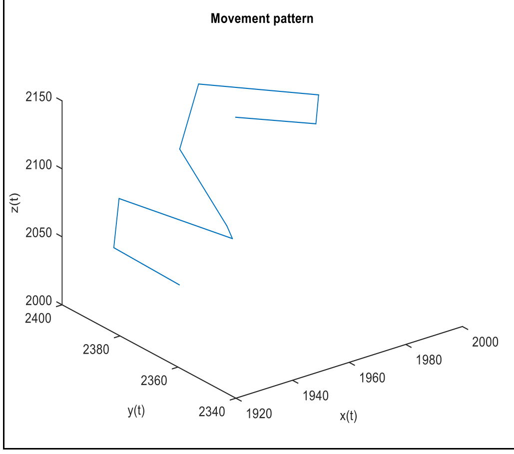
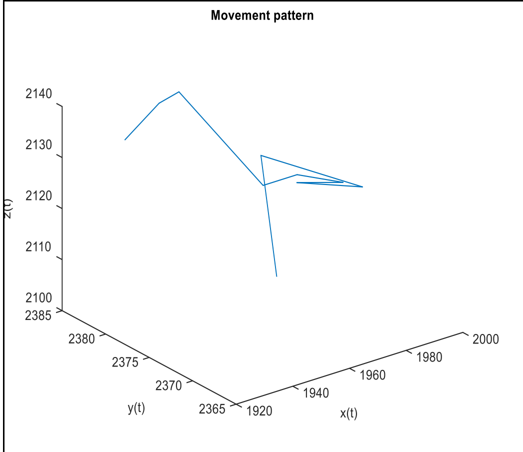
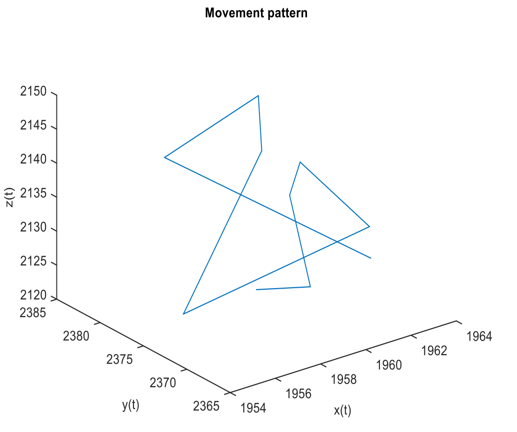


Figure 4-1- Offset changes among the training data movements

the chart	The number of repetitions	start time	Termination time	Coordinates		
				x	Y	z
	3	371	380	1941 1935 1924 1930 1937 1950 1969 1979 1979 1970	2356 2373 2386 2380 2384 2377 2388 2397 2397 2385	**2032 2023 2022 2040 2042 2041 2048 2044 2043 2033**
	5	381	390	1938 1927 1935 1929 1924 1938 1959 1984 1981 1967	2377 2389 2395 2350 2347 2377 2391 2374 2372 2386	**2029 2050 2074 2100 2116 2129 2147 2142 2125 2123**

	4	321	430	1939 1945 1952 1951 1963 1970 1966 1983 1984 1965	2384 2382 2382 2372 2372 2369 2373 2371 2383 2375	**2131 2139 2140 2131 2131 2131 2128 2126 2121 2108**
	4	431	440	1940 1932 1937 1942 1944 1947 1953 1971 1966 1956	2372 2371 2375 2375 2374 2381 2386 2383 2379 2370	**2106 2107 2118 2135 2134 2136 2143 2144 2134 2125**
	3	441	450	1961 1958 1961 1960 1955 1964 1964 1962 1961 1959	2367 2383 2380 2377 2373 2375 2383 2379 2374 2375	**2131 2138 2146 2141 2125 2127 2131 2131 2122 2123**
	3	471	480	1941 1935 1924 1930 1937 1950 1969 1979 1979 1970	2356 2373 2386 2380 2384 2377 2388 2397 2397 2385	**2032 2023 2022 2040 2042 2041 2048 2044 2043 2033**

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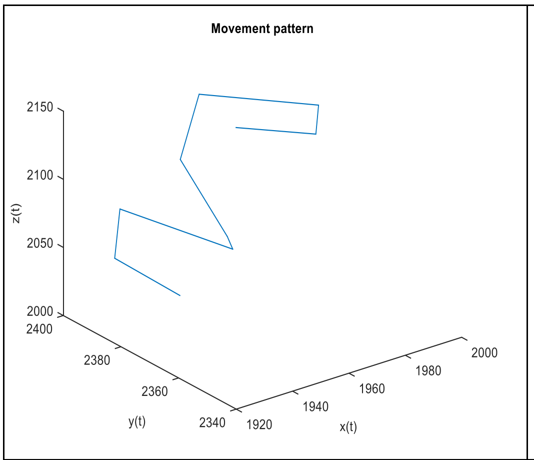
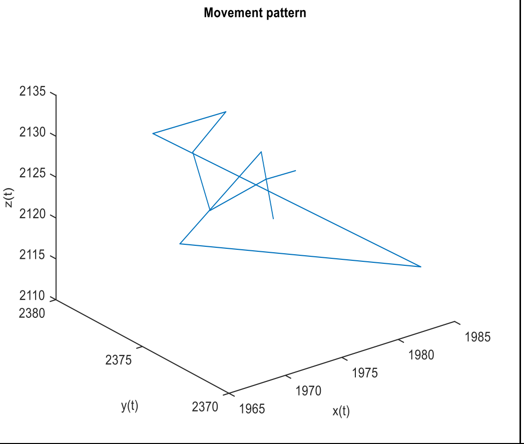
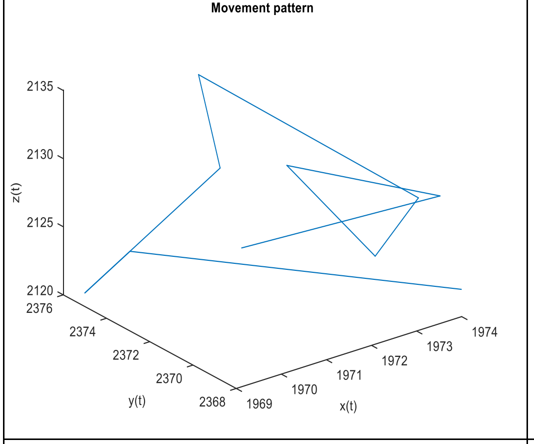
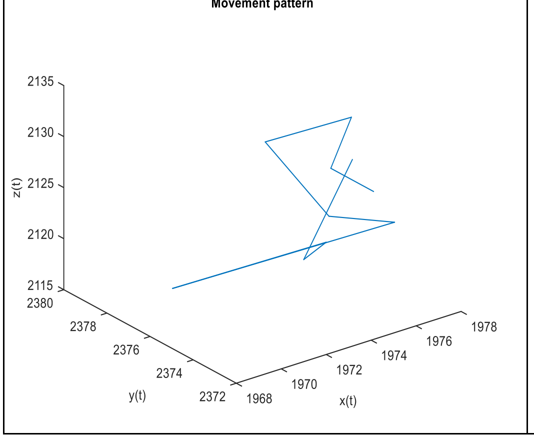
	4	581	590	1938 1927 1935 1929 1924 1938 1959 1984 1981 1967	2377 2389 2395 2350 2347 2377 2391 2374 2372 2386	**2029** **2050** **2074** **2100** **2116** **2129** **2147** **2142** **2125** **2123**
	25	801	810	1974 1979 1971 1971 1977 1969 1982 1976 1974 1972	2372 2377 2375 2376 2378 2377 2370 2380 2374 2372	**2131** **2122** **2124** **2130** **2130** **2132** **2118** **2112** **2131** **2126**
	20	811	820	1974 1970 1969 1972 1972 1974 1974 1973 1974 1972	2368 2375 2375 2375 2376 2370 2372 2374 2369 2374	**2122** **2123** **2121** **2127** **2133** **2127** **2121** **2127** **2128** **2122**
	5	821	830	1977 1977 1976 1976 1975 1976 1969 1972 1971 1977	2375 2377 2375 2379 2375 2373 2376 2372 2372 2376	**2124** **2124** **2132** **2125** **2123** **2124** **2119** **2126** **2125** **2126**

As shown in Table 4-1, the patterns that exist more times than the specified threshold among the set of movements related to a specific activity are extracted. The coordinates of the places where the accelerometer is located during movement in repeated patterns have been determined. With precision in these coordinates, it can be seen that in a specific activity, the displacement of the accelerometer is in an almost certain range, which can identify the type of activity by distinguishing this range.

3-5- Comparison of the proposed method with previous methods

In this research, the proposed method is compared with sources [5-7]. Figure 4-12 shows the comparison between the proposed method and previous methods in terms of performance accuracy.

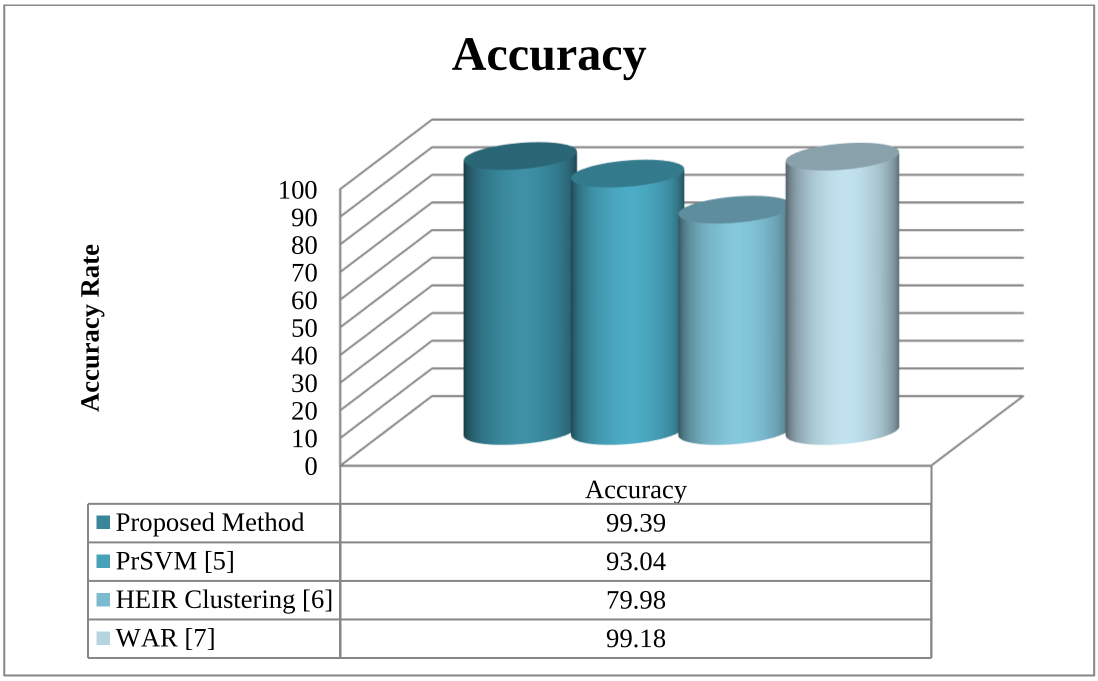


Figure 4-12-Comparison of the performance accuracy of the proposed method with previous methods

The performance accuracy of the proposed method in predicting robot activities has improved by 0.21% from the best human activity detection method available in publications with an accuracy of 99.18% and has an accuracy of 99.39%.

5-Conclusion

Robotics is actually a field of science and technology that refers to robots, and in general we can say that robots are pre-programmed machines that perform a series of tasks automatically or semi-automatically. Robotics is the branch of science that deals with the design, construction and programming of all kinds of machines, and is a small part of its field that is related to artificial intelligence and creates smart robots by integrating with it. Artificial intelligenceis also a branch of computer science that deals with the creation of programs that perform tasks that require human intelligence. Artificial intelligence algorithms have the ability to learn, understand, solve problems, understand natural language or reason logically.

Therefore, in this research, the use of dynamic time deviation algorithm is proposed to adapt the predicted path to track the movement of the robot as the main necessity of the research. The results obtained from the implementation show that the accuracy of the proposed method in predicting the next movements of the robot reaches 99.39%, which is a high accuracy value and is improved by 0.21% compared to the best previous method available in the publications.

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