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# Evaluation of Elderly Fall Detection Systems using Data Analysis

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**Abstract:** As the global population continues to age, it is more important to ensure the safety and wellbeing of senior citizens. Falls are a frequent and dangerous concern for elders, frequently resulting in fatalities or very serious injuries. Modern technology, such as the Elderly Fall Detection System, have been created to solve this issue. This technology attempts to detect falls quickly and react to them, offering aid right away and maybe saving lives. These studies identify a fall when the tri-axial accelerometer reading from a wearable device exceeds the predetermined threshold. Less complexity and computational expense compared to other approaches is one of the main benefits of adopting threshold-based methods. Finding the right threshold value, however, to accurately identify all falls without confounding them with certain ADL, has proven to be a challenging issue. Early Intervention and Medical Aid: Being independent and able to live in one's own house are two things that many elderly people enjoy. Support for carers and peace of mind: detection systems not only aid the elderly but also provide their carers peace of mind. Cost-cutting: Falls among the elderly frequently lead to hospital stays, rehab, and higher healthcare expenses. The Weighted Product Model (WPM) is a technique for ranking and evaluating alternatives based on a variety of factors. It is an easy and obvious method that enables decision-makers to weigh the relative weight of many variables and make wise decisions. Smart surveillance system, Smart cane, Smart Carpet, Smart phone/watch and app. Unobtrusiveness, reliability, privacy, Cost. As the global population continues to age, it is more important to ensure the safety and wellbeing of senior citizens. Falls are a frequent and dangerous concern for elders, frequently resulting in fatalities or very serious injuries The Weighted Product Model (WPM) is a technique for ranking and evaluating alternatives based on a variety of factors Unobtrusiveness, reliability, privacy, Cost, smart phone is the highest and smart carpet is the lowest

**Keyword**: Unobtrusiveness, reliability, privacy, Cost, Smart surveillance system, Smart cane, Smart Carpet, Smart phone/watch and app.

## 1. INTRODUCTION

One of the worst things that may happen to older people is a fall. Fall detection urgently need to be created due to the ageing population that is constantly expanding, especially in industrialized nations. Human-computer interaction with has been viewed as an efficient 7 solution to the issue of fall detection because of the quick growth of sensor networks and the Internet of Things In this article, we present a literature review of research on the use of the Internet of Things to identify senior falls. Despite the fact that there are now 9 different studies that concentrate on the fall detection with specific sensors, such as 10 wearable ones and depth cameras The survey's purpose is to offer an overview of the progress made so far in the field of employing sensor networks to detect elderly falls and to highlight areas that might use more attention. A fall detection algorithm and system have been devised, and they have been integrated into a specially made clothing. A axial accelerometer is used by the newly designed fall detection system to track posture and detect collisions. This is attached to a specially made vest that is intended to be worn below the old person's clothes. The detection algorithm was created and includes the capacity to detect both impact and posture. Two groups of five older test participants each wore the sensor system weeks while being observed for eight hours a day as part of the vest and fall algorithm testing. One of the biggest social and economic issues of the twenty-first century is the ageing population, which has dramatically increased over the previous ten years [1]. The average lifespan of individuals has increased due to advances in medicine and public health services, and during the next 50 years, the percentage of persons over 60 is predicted to double from [2 These people favour ageing at home and preserving their independent lifestyles, which frequently include substantial hazards. T In the elderly population, falls can result in trauma or catastrophic injuries, making them the second most common unintentional cause of post-injury mortality globally. It is essential to provide older individuals with appropriate privacy and comfort in order to keep them under watch. As a result, there is a growing body of research on the detection and prediction of senior falls utilising wearable and non-wearable sensors. This study suggests a unique pathway for fall detection using data from wearable accelerometers. For each of the three publicly accessible datasets utilised to test our proposed technique, more than disciplinary time-series characteristics were examined. We have acquired the dominating features for each dataset after applying a number of feature reduction strategies, including mutual information, deleting strongly correlated features using the Pearson correlation coefficient, and the. Based on the acquired characteristics, various traditional machine learning methods were used to identify falls. The straightforward ML classifiers produced extremely excellent accuracy for individual datasets. To demonstrate the generalizability of our suggested pipeline, we used all three datasets as the test set after training with two of the three datasets and testing with the third dataset. The classifiers were trained using a collection of 39 characteristics that were highly effective. The suggested pipeline demonstrated great efficiency in identifying falls in each and every case. This design outperformed the majority of previous efforts across all datasets that were tested and were made publicly available, demonstrating the superiority of the suggested data analysis pipeline. The World Health Organisation claims that The second most common reason for accidental or unintentional injury fatalities globally is falls. Adults over 65 account for the majority of fatal falls. Therefore, the use of automatic fall systems can enhance the quality of life for senior citizens. This study describes a fall detection device that keeps an elderly person under constant watch. The system identifies two main parts: a cell phone and a wearable gadget. The wearable may be located within a radius and is capable of interacting with a cell phone. When a fall is detected, the wearable. The major goal is to eliminate the constant necessity to carry a cell phone. Additionally, our system contains a panic button that the user may press to notify the emergency personnel in the case that they believe a fall is imminent. For the elderly. An elderly person's mobility, freedom, and quality of life can all suffer significantly after a fall if timely assistance is not provided. In this regard, the current study suggests a novel. The system automatically responds by sending messages to the organisations in charge of caring for the elderly when a fall is detected, activating an alert. Finally, the system offers From a medical standpoint, there is a storage service that gives access to falls data to healthcare professionals so they may undertake additional analysis. However, the system also offers a service that uses this data to build a fresh model each time a fall is discovered. Experiments' findings indicated that fall detection had good success rates in terms of accuracy, precision, and gain. The "long lie," which involves being on the ground for extended periods of time before aid comes, is a hazardous consequence of taking a fall. Dehydration, pneumonia, and hypothermia are just a few of the major health problems that the "long lie" can cause. In many cases, these conditions can result in death within six months after a fall. As a result, an aged person's independence and quality of life may suffer from a fall that is not promptly attended to 4. IoT solutions that help detect falls and promptly notify emergency personnel are needed in this situation. Currently, a number of strategies for detecting geriatric falls have been put forth. According to the sensor technology employed, these solutions are divided into three primary categoriesare particularly effective and reliable at spotting falls. The primary drawback of these systems, however, is their high cost and resulting lack of privacy for older individuals because they need strategically placing sensors around the senior's interior living space. The use of inertial sensors, such as accelerometers and gyroscopes, which are commonly affixed to the bodies of the elderly for movement identification when a fall occurs, has been advocated in WS systems like those in 8-9 and 10 to get around this constraint. Because of its benefits, including as low power consumption, cheap cost, low weight, simplicity of use, compact size, ability to be installed on multiple body sites, and, most significantly, portability, accelerometers are being employed more and more in WS systemsThese studies identify a fall when the tri-axial accelerometer reading from a wearable device exceeds the predetermined threshold. Less complexity and computational expense compared to other approaches is one of the main benefits of adopting threshold-based methods. Finding the right threshold value, however, to accurately identify all falls without confounding them with certain ADL, has proven to be a challenging issue.

## 2. MATERIAL AND METHOD

The Weighted Product Model (WPM) is a technique for ranking and evaluating alternatives based on a variety of factors. It is an easy and obvious method that enables decision-makers to weigh the relative weight of many variables and make wise decisions. Methods that are frequently used to support decision-making include Weighted Product Much research have compared the two approaches; one of them is the one by Tran and Boukhatem, which compared Multi Attribute Decision Making decision algorithms for interface selection in heterogeneous wireless networks. It demonstrates that their approaches may provide the optimal network selection solution [10]. According to Vyas and Misal's research, TOPSIS is believed to be very intuitive and takes into account distance and the ideal solution, whereas WP is able to handle single or issues and utilise the actual data to determine the rating of each alternative for each criterion. Methods that are frequently used to support decision-making include

Weighted Product (WP) and Technique for Order Preference by Similarity to Ideal Solution. For example, TOPSIS is used to rate providers assess optimal generation and rank qualities or criteria. WP is used in the meanwhile to compute attribute weights [8], assess optimal generation [7], and evaluate the optimal generation for a certain day [9]. Numerous research have compared the two approaches; one of them is the one by Tran and Boukhatem, which contrasted Multi Attribute Decision Making decision algorithms for interface selection in heterogeneous wireless networks. It demonstrates that their approaches may provide the optimal network selection solution [10]. According to Vyas and Misal's research, TOPSIS is seen to be very intuitive with considerations for distance and the optimum solution, whereas WP is able to handle single- or multi-dimensional issues and utilise the actual numbers to determine the rating of each alternative for each criterion. In the majority of real-world situations, procurement auctions frequently let the contracts to be chosen based on a number of criteria, including price, quality, lead time, contract terms, supplier reputation, and incumbent switching costs For instance, while negotiating a deal for a new fighter jet, design elements are at least as significant as pricing. Suppliers or businesses vying for contracts from the to procure weapon systems must include in their bids information about the promised technical capabilities of their aircraft, the delivery date, and managerial performance, in addition to an Public works allocation decisions are therefore not solely based on project costs [6]. Similar to goods, services may be distinguished by their quality, speed of delivery, and degree of risk associated with the transaction. To a base station, these sensor nodes gather, analyse, and transmit the data. These sensor nodes essentially collect environmental data. Other intermediary nodes are used to gather these data and send them to their final destination. From the data source, the data packets are received and sent to the base station. Route finding is the primary network transmission technique support in multi-hop scenarios. An effective routing algorithm is crucial in a WSN. However, due to the network's numerous routing factors and the sensor node's restricted resources, the realisation of the same is not as simple.

The numerous WSN limitations create a set optimisation challenge when creating algorithms for routing that are energy efficient. Some WSN routing methods choose the next hop by taking into account just one factor, such as energy [2], distance [3], or both [4]. However, they are unable to balance the energy use. Thus, the next hop is often chosen at random or based on node density, residual energy, or distance from the sink node for the majority of the present routing algorithms. Other crucial performance indicators from the sink node may be compared if the next hop is chosen based on remaining energy. to other nodes that are close by. In this scenario, if the path length (i.e., hop count) rises, the end-to-end latency will also increase. With the help of the Weighted Product Model (WPM), decision-makers may assess and evaluate options depending on a variety of factors. It offers a methodical methodology for weighing the relative significance of different variables and making wise selections. Finding the criteria that are pertinent to the decision-making process is the first stage in the WPM. Depending on the particular issue or setting at hand, these standards may change. They stand in for the many qualities or considerations that must be made while weighing the available options. For instance, while choosing a new vehicle, factors including the cost, fuel efficiency, safety features, and brand reputation may be taken into account. Decision-makers give each criterion a weight after identifying them to represent their relative importance. Usually, the decision-makers' tastes and top priorities are taken into account while determining these weights. When criteria are given more weight, it means that they will have a bigger influence on the choice. For instance, if safety is seen to be of the utmost importance, it can be given more weight than other consideration s The performance of each alternative is then assessed in light of the established criteria. Depending on the nature of the criterion and the availability of data, this review may use quantitative measurements or qualitative judgements. Numerical numbers can be compared for quantitative criteria like cost or fuel economy. Contrarily, qualitative criteria may call for subjective evaluations or qualitative assessments, such as brand reputation or customer satisfaction. The performance values of the alternatives for each criterion are multiplied by the corresponding weights in the WPM to provide an overall score for each option. The overall score for each choice is then calculated from these individual scores. The option with the greatest overall score is regarded as the best one.

Unobtrusiveness refers to the quality of being inconspicuous, discreet, or not causing interference or disruption. It is often used to describe objects, technologies, designs, or behaviors that blend seamlessly into the background or environment without drawing excessive attention. The capacity of a system, process, or item to carry out its intended purpose consistently and accurately throughout time is referred to as reliability. Consistent performance is critical in many areas, including engineering, manufacturing, technology, and the service sector, where it is necessary for customer pleasure, safety, and efficiency.The right of people to manage who has access to, uses, and discloses their personal information is referred to as their right to privacy. It includes safeguarding private information, safeguarding sensitive data, and protecting the security and privacy of personal data.Information on costs involved in obtaining, manufacturing, or sustaining products, services, or projects is referred to as cost information. It is essential to financial analysis, budgeting, decision-making, and determining a project's viability or profitability.

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## 3. RESULTS AND DISCUSSION

**TABLE 1.** Evaluation of Elderly Fall Detection Systems

| | unobtrusiveness | reliability | privacy | Cost |
|---|---|---|---|---|
| Smart surveillance system | 0.2622 | 0.9520 | 0.0663 | 0.4965 |
| Smart cane | 0.6716 | 0.4540 | 0.0051 | 0.7917 |
| Smart Carpet | 0.4363 | 0.0149 | 0.2046 | 0.4221 |
| Smart phone/watch and app | 0.9587 | 0.6488 | 0.8505 | 0.2706 |

Table 1 evaluates four systems based on four criteria: unobtrusiveness, reliability, privacy, and cost. Unobtrusiveness: This criterion measures how discreet and non-intrusive the fall detection system is. Smart surveillance system: Scored 0.2622, indicating a relatively low level of unobtrusiveness. Smart cane: Scored 0.6716, suggesting a higher level of unobtrusiveness compared to the smart surveillance system. Smart Carpet: Scored 0.4363, indicating a moderate level of unobtrusiveness. Smart phone/watch and app: Scored 0.9587, suggesting the highest level of unobtrusiveness among the listed systems. Reliability: This criterion measures how dependable and accurate the fall detection system is. Smart surveillance system: Scored 0.9520, indicating a high level of reliability. Smart cane: Scored 0.4540, suggesting a relatively lower level of reliability compared to the smart surveillance system. Smart Carpet: Scored 0.0149, indicating a significantly lower level of reliability. Smart phone/watch and app: Scored 0.6488, suggesting a moderate level of reliability compared to the smart surveillance system. Privacy: This criterion measures the level of protection of users' privacy while using the fall detection system. Smart surveillance system: Scored 0.0663, suggesting a relatively low level of privacy. Smart cane: Scored 0.0051, indicating a higher level of privacy compared to the smart surveillance system. Smart Carpet: Scored 0.2046, suggesting a moderate level of privacy. Smart phone/watch and app: Scored 0.8505, indicating a relatively high level of privacy compared to the other systems. Cost: This criterion measures the cost associated with implementing the fall detection system. Smart surveillance system: Scored 0.4965, indicating a moderate cost. Smart cane: Scored 0.7917, suggesting a higher cost compared to the smart surveillance system. Smart Carpet: Scored 0.4221, indicating a relatively lower cost. Smart phone/watch and app: Scored 0.2706, suggesting the lowest cost among the listed systems. It's important to note that the interpretation of the scores may depend on the specific scale used for evaluation in the original study or context in which the table was created.

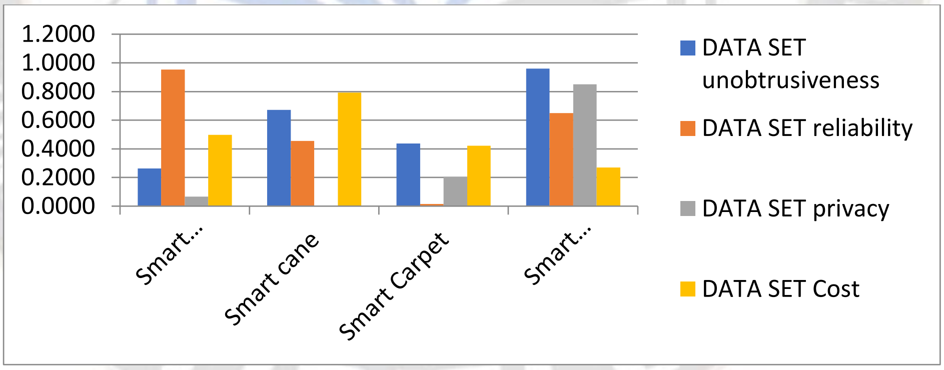


**FIGURE 1.** Smart surveillance systems are more than others.

Figure 1 evaluates four systems based on four criteria: unobtrusiveness, reliability, privacy, and cost. Unobtrusiveness measures how discreet and non-intrusive the fall detection system is. Smart surveillance system scored a relatively low level of unobtrusiveness. Smart cane scored a higher level of unobtrusiveness compared to the smart surveillance system. Smart Carpet scored a moderate level of unobtrusiveness. Smart phone/watch and app scored the highest level of unobtrusiveness among the listed systems. Reliability measures how dependable and accurate the fall detection system is. Smart surveillance system scored a high level of reliability. Smart cane scored a relatively lower level of reliability compared to the smart surveillance system. Smart Carpet scored a significantly lower level of reliability. Smart phone/watch and app scored a moderate level of reliability compared to the smart surveillance system. Privacy measures the level of protection of users' privacy while using the fall detection system. Smart surveillance system scored a relatively low level of privacy. Smart cane scored a higher level of privacy compared to the smart surveillance system. Smart Carpet scored a moderate level of privacy. Smart phone/watch and app scored a relatively high level of privacy compared to the other systems. Cost measures the cost associated with implementing the fall detection system. Smart surveillance system scored a moderate cost. Smart cane scored a higher cost compared to the smart surveillance system. Smart Carpet scored a relatively lower cost. Smart phone/watch and app scored the lowest cost among the listed systems.

**TABLE 2.** Normalized matrix

| | unobtrusiveness | reliability | privacy | Cost |
|---|---|---|---|---|
| Smart surveillance system | 0.27354 | 1.00000 | 0.07796 | 0.62719 |
| Smart cane | 0.70053 | 0.47687 | 0.00597 | 1.00000 |
| Smart Carpet | 0.45508 | 0.01561 | 0.24062 | 0.53322 |
| Smart phone/watch and app | 1.00000 | 0.68154 | 1.00000 | 0.34180 |

Table 2 shows the normalized matrix value of data set for evaluation of elderly fall detection systems. This is calculated according to the Weighted product method.

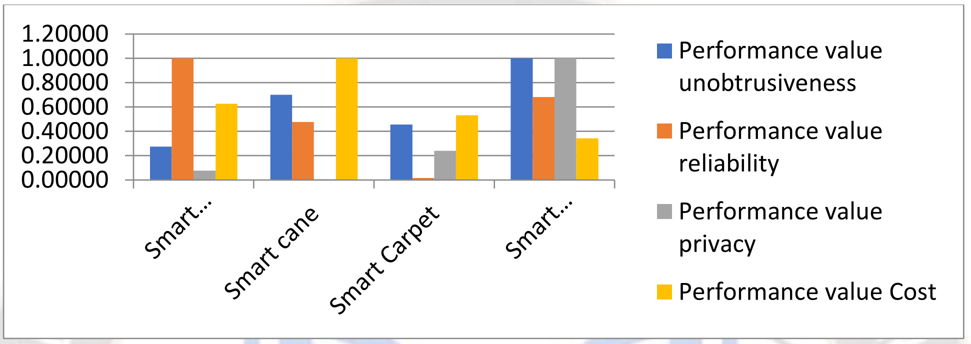


**FIGURE 2.**Normalized matrix.

Figure 2 shows the normalized matrix value of data set for evaluation of elderly fall detection systems. This is calculated according to the Weighted product method.

TABLE 3. Weight array

| | Weight | | | |
|---|---|---|---|---|
| | unobtrusiveness | reliability | privacy | Cost |
| Smart surveillance system | 0.25 | 0.25 | 0.25 | 0.25 |
| Smart cane | 0.25 | 0.25 | 0.25 | 0.25 |
| Smart Carpet | 0.25 | 0.25 | 0.25 | 0.25 |
| Smart phone/watch and app | 0.25 | 0.25 | 0.25 | 0.25 |

Table 3 show the weight preferred for evaluation parameters taken for the evaluation of elderly fall detection systems in this paper. Here the sum of weight preferred for the evaluation parameters is one. Weight is equally distributed among the evaluation parameters.


**FIGURE 3**. Weight matrix

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Figure 3 show the graphical representation of the weight preferred for evaluation parameters taken for the evaluation of elderly fall detection systems in this paper. Here the sum of weight preferred for the evaluation parameters is one. Weight is equally distributed among the evaluation parameters.

**TABLE 4.** Weighted normalized decision matrix.

| | unobtrusiveness | reliability | privacy | Cost |
|---|---|---|---|---|
| Smart surveillance system | 0.72319 | 1.00000 | 0.52841 | 0.88992 |
| Smart cane | 0.91487 | 0.83100 | 0.27794 | 1.00000 |
| Smart Carpet | 0.82134 | 0.35347 | 0.70038 | 0.85453 |
| Smart phone/watch and app | 1.00000 | 0.90860 | 1.00000 | 0.76461 |

Table 4 shows the weighted normalized matrix value of data set for evaluation of elderly fall detection systems. This is calculated according to the Weighted product method by multiplying weight matrix and normalized matrix.

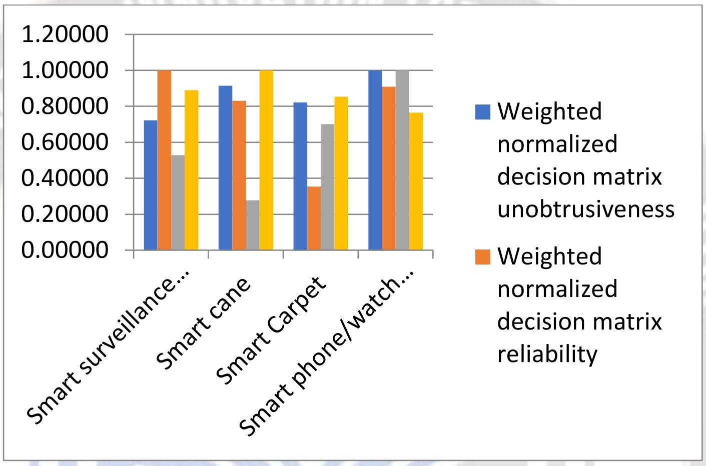


FIGURE 4. smart watch is more as compared to others.

Figure 4 shows the graphical representation of the weighted normalized matrix value of data set for evaluation of elderly fall detection systems. This is calculated according to the Weighted product method by multiplying weight matrix and normalized matrix.

TABLE 5. Preference score

| | Preference Score |
|---|---|
| Smart surveillance system | 0.34007 |
| Smart cane | 0.21131 |
| Smart Carpet | 0.17376 |
| Smart phone/watch and app | 0.69473 |

Table 5 shows the preference values for evaluation of elderly fall detection systems. Here the preference value for smart surveillance systems is 0.34007, smart cane is 0.21131, smart carpet is 0.17376 and smart phone/watch and app is 0.69473. here smart phone/watch and app has the best preference score while smart carpet has the worst preference score.

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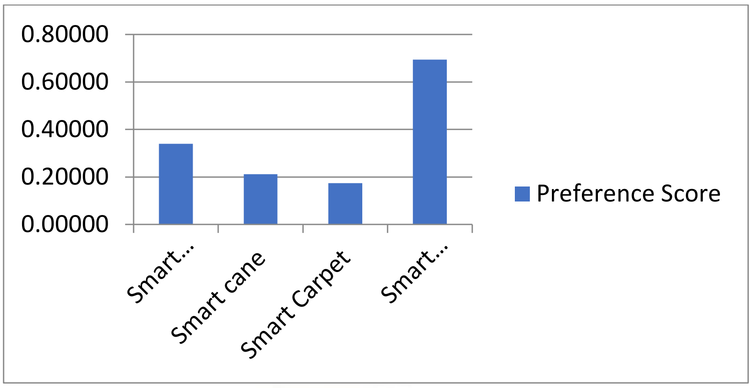


Figure5. Preference score.

Figure 5 shows the graphical representation of the preference values for evaluation of elderly fall detection systems. Here the preference value for smart surveillance systems is 0.34007, smart cane is 0.21131, smart carpet is 0.17376 and smart phone/watch and app is 0.69473. here smart phone/watch and app has the best preference score while smart carpet has the worst preference score.

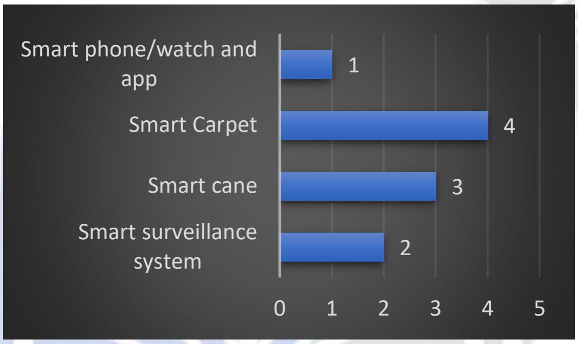


**FIGURE 6.** Rank

Figure 6 shows the graphical representation of the rank for evaluation of elderly fall detection systems. Here the rank for smart surveillance systems is second, smart cane is third, smart carpet is fourth and smart phone/watch and app is first. here smart phone/watch and app has the performance while smart carpet has the worst performance.

## 4. CONCLUSION

As the global population continues to age, it is more important to ensure the safety and wellbeing of senior citizens. Falls are a frequent and dangerous concern for elders, frequently resulting in fatalities or very serious injuries. Modern technology, such as the Elderly Fall Detection System, have been created to solve this issueThe Weighted Product Model (WPM) is a technique for ranking and evaluating alternatives based on a variety of factors. It is an easy and obvious method that enables decision-makers to weigh the relative weight of many variables and make wise decisions. Methods that are frequently used to support decision-making smart phones are the highest and smart carpet is the lowest.

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