BAB I
INTRODUCTION

1.1. Background

The elderly are people who age above 60 years old according to the Indonesian Government of Law in Number 13 of 1998 [1]. Based on data from BPS (Badan Pusat Statistik), in five decades (1971-2020), the percentage of the elderly population increases by 29%, approximately 26 million people [1]. The number of older women is greater than that of the older men; the percentages of older women and older men are 10.43% and 9.42%, respectively [1]. In addition, the elderly aged 60-69 years old have a higher percentage in population, i.e., 27.23%, compared to the elderly aged 70-79 years old (8.49%) [1]. There are many health issues that the elderly could experience [1]. The elderly also tends to be fragile and prone to injury [1], [2]. Falls and pressure ulcers (PU) are two conditions that often cause the elderly to suffer [3], [4]. Both Falls and PU can cause trauma on older people and the injuries take a long time to treat [4]–[6].

Almost 50% of fall incidents in the elderly occur while the subject is walking, and the remaining 50% occur while the subject is standing still [6]. Fall incidents in older people also often happen in the toilet [7]. Falls in the elderly while walking can potentially cause large-scale TBI (Traumatic Brain Injury), compared to fall during standing still, although both conditions similarly cause TBI [6]. In addition, falls have even a worse effect than just TBI, it can be fatal if not treated immediately [5]–[7]. As for PU, it is usually caused by prolonged sleeping positions for an extended period. PU treatment is periodically changing the sleeping position to reduce pressure on the skin and reduces surface temperature [4]. The worst effect is that PU induces risk of creating open sores on the skin, often occurring in the elderly with disabilities [4], [8]. A nurse usually carries out PU treatment by changing the position of the elderly body every two hours, when sleeping or sitting regularly, and providing special pads on the bed or seat [8], [9]. Falls and pressure sores that usually occur in the elderly require a long time to heal and are expensive [6], [8].

Some used methods and techniques are to perform the immediate treatment to minimize the adverse effects of falling conditions, including acceleration sensors, wearable devices, radar, and vision with thresholding classification techniques, machine learning (ML) or deep learning (DL) for sequence learning [10], [11]. Thresholding techniques are more susceptible to false alarms than ML and DL [10], [12]. The accuracy results in fall detection using ML; the best method is using an acceleration sensor, and the worst is vision combined with ML or DL [11]. However, image is more flexible than acceleration sensors [10]–[12]. HAR (human activity recognition) is a vision technique for human activity monitoring [13]. One of the HAR techniques resistant to environmental changes and sudden movements is pose estimation [12], [13].

Based on previous research, there are several methods for PU detection, such as using pressure tiles and capacitive sensors to detect pressure on the body's limbs and profile the impact of the pressure exerted on each body part, using pressure sensors with sleep posture classification. Some even use FBG (Fiber Bragg Grating) sensors validated with thermal cameras on patients who are in wheelchairs. However, previous studies have only focused on detecting and mapping the possibility of PU, and none have focused on reducing the impact or prevention caused by PU [14]–[17].

Based on these problems, a system monitors the elderly. It provides alerts to nurses or families to take immediate action on the incidence of falls and potential pressure ulcers (PU) due to the length of sleep position. The monitoring system is also not only for activities limited to indoors but also outdoors.

In this study, a developed in-house Elderly Care System can help monitor activities, provide alerts in the event of a fall, and predict the incidence of falls for immediate handling treatment. The system also helps monitor PU and provides alerts to change sleeping positions to prevent PU from becoming more severe.

The system consists of 2 main sub-systems: indoor and outdoor. The indoor system consists of two sub-systems: a monitoring sub-system with a camera for activity recognition and a mechanical bed to help rehabilitate older people with disabilities so that PU can be prevented by more easily changing the sleeping

position of the elderly. The Indoor System consists of a mobile application as a user interface for families or medical personnel to find out the activities of the elderly in the room and provide alerts. It needs immediate treatment if the elderly experience falls, falls in the toilet (too long in the bathroom), and PU due to sleeping positions that are too long (elderly with disabilities). The user interface in the mobile application can also be used to control the mechanical bed so that preventing pressure ulcers by changing the sleeping position is more manageable. Sleeping positions on a motorized bed consist of 12 places, i.e., Assisting to stand-up, Sitting, Fowler, Semi-Fowler, Anti-Trendelenburg, Orthopedic, Trendelenburg, Cardiac, Foot Elevation, Tilt to The Right, Tilt to The Left, dan Normal. The Outdoor system is specifically for outdoor activities. The outdoor system is embedded with an IMU sensor to detect dangerous activities such as falling while walking and falling (unstable) while standing; it is also equipped with a camera for monitoring the location of the incident or location around, and GPS to see the coordinates or location of the elderly fall. An additional feature of the outdoor system is the user interface in the mobile app for fall alerts to family or medical personnel for immediate treatment. The system will provide alerts through buzzer sounds to older people as users. Signs are used for notifications on dangerous activities (falling and unstable) and non-dangerous activities (walking and stable).

1.2. Problem Identification

From the description of the background, the author can formulate several problems in this thesis, including the following:

1. How is an indoor system designed for an elderly activity monitoring subsystem with a camera for immediate action on falling conditions and pressure sore prevention measures for older people treated in the room?
2. How is an outdoor fall prediction system designed for immediate treatment?

1.3. Objectives

From the formulation of the problem, the author can formulate several objectives and issues in this thesis, including the following:

1. We are designing an Indoor system for activity monitoring (walking, falling, going in and out of the room, going in and out of the toilet, and sleeping position (supine and facing left - right)) in the elderly, which is equipped with an android application for activity monitoring and fall alerts with an android application, as well as pressure ulcer prevention with a mechanical bed that can change the position, level and tilt of the bed, as well as a variety of default modes that can be controlled with an android application or with buttons on the bed.
2. Designing an outdoor system for predicting falling conditions in the elderly, equipped with a warning system using a buzzer and an android application, and additional features for location tracking with GPS and area capture if needed.

1.4. Scope Limitations

The problem limitations that the author uses in this thesis are as follows:

1. The camera monitoring sub-system of the Indoor System is limited to monitoring the activities of one person.
2. Elderly activities observed with the camera are only inside the room, while outside the room with the inertial sensor.
3. The activities of the elderly that are used as parameters for monitoring with the camera are sleep, duration of the sleep position (sleep facing up, sleep facing left, and sleep facing right), walking, exiting the room, entering the toilet, and falling.
4. Falling position data consists of falling forward, falling to the right side, and falling to the left side. This is because falling towards the back rarely occurs in older people.
5. The dataset for training activity prediction models in the monitoring sub-system with cameras and outdoor systems is independent data.
6. The outdoor system does not support older people with a hunched posture condition because the dataset is independent data with a normal posture.
7. The data processed in the camera monitoring sub-system is a real-time video with a delay below 100 ms and a frame rate of at least 25 FPS.
8. The feature data for activity recognition in the Outdoor System uses acceleration and gyroscope inertial sensors.

9. The camera angle has been set to 20˚ for the camera monitoring sub-system.
10. The bed position consists of 12 movements: Help to Stand-Up, Sitting, Fowler, Semi-Fowler, Anti-Trendelenburg, Orthopedic, *Trendelenburg*, Cardiac, Foot Elevation, Tilt to The Right, Tilt to The Left, and Normal.
11. The position on the bed can only be moved with a wirable remote and smartphone for remote control.
12. The weight limit for the mechanical bed is less than or equal to 90 kg. That is because the used linear motor has a maximum weight specification of 100 kilograms of the support part.

1.5. Methodology

The design method used is as follows:

1. Identify and analyze the problem that is the subject of research and the method used to solve it with existing information from various reliable sources.
2. Design hardware and software to meet the needs of the system being created.
3. After the design is complete, proceed with implementing hardware, software, and testing.
4. In testing, the results are in the form of data that can be used in the discussion to determine whether the system research is appropriate.

1.6. Research Methods

Based on the research methods that have been carried out, several methods are under each sub-system, which are explained as follows:

1. Several methods have been used for human monitoring in the camera monitoring sub-system. Some of these methods include feature extraction from video and pose estimation. Characteristic extraction, such as with CNN, will experience problems when used in changing environmental conditions and sudden movements in real-time. However, pose estimation provides robustness against changing environmental conditions and sudden movements. However, it only applies to 3D pose estimation, and 2D pose estimation has the

disadvantage of wild movements in the activity. In addition, deep learning, or DL, is proposed to correct the wild movement of the activity.

2. In outdoor systems or activity monitoring with inertial sensors, several methods have been proposed in previous studies, such as threshold, ML, and DL. However, hammer or false alarms often occur in systems using the threshold method, and using the ML algorithm and, even better DL is more advisable. In addition, some sources say the best DL algorithm for classification is ANN, but other algorithms can be more potent if used correctly.
3. In the bed sub-system for pressure sores or elderly disabilities, several studies have been conducted, and most of them are mapping pressure sores but not preventing or warning pressure sores. Some efforts are made, such as the use of pressure sensors and temperature sensors to map the location.

1.7. Contributions

This thesis focuses on the development of an elderly care system consisting of vision devices, wearable devices, and bad mechanical. The vision device aims to monitor the activities of the elderly. It will warn families or nurses if they fall and preventive measures for PU by warning them of their sleeping position. Meanwhile, wearable devices are used for indoor-outdoor elderly detection and prevention, such as tracking and warning of falls in the elderly. In addition to the wearable device warning, it will warn the elderly if their balance condition is abnormal, which can cause a fall using a buzzer. The last is bad mechanical, and this tool is used as a mechanical helper to make it easier to change the position of the elderly for PU rehabilitation.