SYMPOSIUM PRESENTATION 2: MOBILITY AND TRANSPORT

Technology use for assessing mobility among older adults
M. Choi (Convener)

Participants*:* Four Korean researchers will give presentations on their work as follow: K. Jang, J.-G. Lee, C. Lee and M. Kang. **ISSUE** Mobility is critical for quality of life among older adults. Walking and driving abilities enable older adults to participate in society. Classic assessment tools such as Katz Index of Independence in Activities of Daily Living (ADLs)—in particular the item of transferring—have contributed to enhancing the knowledge related to mobility among older adults. However, the advancement of technology calls for alternative way to assess mobility among older adults. **CONTENT** This symposium aims to present the use of technology in assessing mobility among older adults in a twofold way: (a) machine learning application into big data and (b) use of wearable robot. **STRUCTURE** The first two presentations focus on older drivers. K. Jang's research group will present their research findings about driving characteristics of taxi drivers by age groups based on the application of deep learning-based analysis into a large-scale naturalistic data of driving. J.-G. Lee's research group will discuss the differences in driving offenses across four age groups of older taxi drivers using the data from Digital Tachograph (DTG) devices. The second two presentations address the use of wearable robot. Y. Kim's research group will give two presentations, and the first one will present a multi-dimensional mobility evaluation system for people in later life by using an exercise exoskeleton robot. The last presentation will show reliable indicators for evaluating muscle activation using wearable robot. **CONCLUSION** The advancement of artificial intelligence and robots would contribute to assessing mobility and driving abilities among older adults in a more accurate way. This symposium introduces novel applications of existing technologies in assessing functions of older adults both in micro and macro ways.

Keywords: mobility, transport, driving, older driver, wearable robot, exoskeleton robot
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Do older people drive differently? Analysis of driving characteristics of taxi drivers on urban roads

J. Lee, K. Jang

Purpose As the portion of the aged population grows rapidly in South Korea, traffic injuries that are caused by older drivers have emerged as a public concern because the number of traffic crashes and injuries has increased. Older drivers have, in general, a degraded driving performance that reduces their ability to avoid risks (McGwin et al., 2000). As a result, their driving can be characterized as slow driving speed and wide deceleration and acceleration range (Horberry et al., 2006). However, the driving characteristics of older drivers were not fully unveiled due to data limitations. The objective of this study is to use large-scale actual driving records of older drivers to characterize the driving characteristics of older drivers and compare them with other drivers. **Method** The large-scale driving records of taxi drivers are collected using a digital tachograph (DTG), a naturalistic driving data collection device installed on commercial vehicles. Since DTG records vehicle speed, acceleration, steering angle, and location information every second, it is possible to analyze the driving patterns of drivers. In particular, these driving patterns are multidimensional data with non-linear characteristics (Chen et al., 2019). Therefore, to reflect on the attributes of the data and analyze the driving characteristics of drivers, a deep learning-based analysis methodology needs to be used. In this study, the normal driving patterns of taxi drivers are categorized using convolutional autoencoder-based deep clustering. In addition, an abnormal driving score is derived for each driving behavior, and driving characteristics according to drivers' age are analyzed. **Results and Discussion** Driving behaviors were characterized by different age groups. For the drivers whose age is 60 or older, the portion of abnormality – deviation from the normal driving behavior – increased in their acceleration and deceleration. It means that older drivers tend to be more frequent and have harsh pedal operations due to cognitive decline. On the other hand, the abnormality diminishes for drivers of 70 years or older in right-turning cases. The results of this study confirmed that the driving behavior varies according to the driver's age. Therefore, when establishing safety driving education programs and policies for older drivers, it is necessary to consider the differences in driving characteristics according to age.

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Keywords: driving characteristics, driving record, deep clustering, abnormal driving

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Analysis of dangerous driving behavior per driver age with taxi driving log data

A. Son, J.-G. Lee

Purpose Elderly driving has emerged as one of the critical social issues, and the number of traffic accidents caused by elderly drivers increases year by year. The accidents caused by the drivers over the age of 60 took 25% of all accidents in 2019 in South Korea (TS, 2019). Dangerous driving behavior is highly correlated with traffic accident risk (Trirat & Lee, 2021). Thus, this study aims to identify the differences in dangerous driving behavior among four age groups: below 60, from 60 through 64, from 65 through 69, and above 70. **Method** The taxi driving log data was collected by 1,424 taxi drivers using Digital Tachograph (DTG) devices over 29 days from August 1, 2018 through August 29, 2018 in a certain city of South Korea. Features about nine dangerous driving offenses are extracted from the DTG log data, and the label is determined as the age group of the taxi driver. Then, a prediction model is trained using XGBoost so as to find the relationship between dangerous driving behavior and driver age. Investigating the contribution of each feature to the model can reveal which dangerous driving behavior changes by age. **Results and Discussion** The overall ratio of dangerous driving behavior between the group of 'below 60' and any other group is statistically significant ($p < 0.05$). When observing each of the nine dangerous driving offenses separately, a similar result was obtained for the ratios of over-speeding, quick start, rapid deceleration, and sudden stop. The prediction model, which was trained with only dangerous driving behavior, achieved an accuracy of 37.94% using the ten most important features. A deeper analysis shows that the ratio of rapid acceleration, the time of evening, and the ratio of quick start played a key role in discriminating the age groups. The insight from this study is expected to be useful for implementing new policies for elderly drivers.

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Keywords: dangerous driving behavior, digital tachograph (DTG), statistical analysis, elderly driver
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Mobility evaluation system based on anomaly detection using an exercise exoskeleton robot

C. Lee, B. M. Kang, S. Joo, Y. Kim, D. E. Kim, G. J. Kim, Y. M Lim

Purpose. An evaluation system of mobility can help check abnormal mobility and functional trajectories in aging processes. Moreover, an exercise exoskeleton robot has the potential to measure mobility function if it contains an appropriate evaluation system. It is because it provides ergonomic structural support allowing for sufficient limb movement with manipulating strength by power, and it already has its own sensor systems related to mobility (Wang et al., 2022). However, previous evaluation systems for mobility usually focus on a single feature of mobility, and some of them estimate mobility function based on no actual data but simulation data. Thus, this study aims to develop a multi-dimensional mobility evaluation system using an exercise exoskeleton robot based on actual data related to mobility among people in later life. **Method**. Participants were 20 people (10 men and 10 women) aged 56 to 74 without musculoskeletal disorders. They performed a walking test at a self-selected speed with wearing the GEMS-H exercise exoskeleton robot (Seo et al., 2016) without resistance. During the walking test, changes in motor joint angle, 9-axis Inertia Measurement Unit (IMU), and personal information (e.g., exercise performance score, weight, and gender) were recorded. There were four critical features of the multi-dimensional mobility function: balance, stability, flexibility, and power. The balance score was the symmetry between all the left and right of features. The flexibility meant the range of motion of the motor. The power was calculated as a relative value by integrating the acceleration of the motor and the subject's weight. Finally, the stability indicated the changes in the low frequency. After rectifying and regularizing raw values, we converted four features into each interpretable score based on physical modeling. **Results and Discussion**. We propose a mobility evaluation system based on anomaly detection with four indicators (balance, stability, flexibility, and power). The multi-dimensional gait data from the exercise exoskeleton robot and isokinetic exercise by walking are useful for creating the mobility evaluation system. All indicators (balance, stability, flexibility, and power) are relative values, but they are very suitable for measuring anomalies based on the data distribution collected by the same protocol. The present study is significant because it suggests a multi-dimensional mobility evaluation system for people in later life by using an exercise exoskeleton robot. However, additional studies are also needed to validate this emerging system with more generalized standard data.

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Keywords: wearable hip-assist robot, dynamic time warping, short-time fourier transform, anomaly detection
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Evaluation method using muscle activation of resistance exercise with wearable robot

B. Kang, C. Lee, S. Joo, J. Y. Kim, D. E. Kim, G. J. Kim, Y. M. Lim

Purpose Muscle strength plays a key role in mobility and independent living in human aging processes. An effective evaluation method of muscle activation is important to estimate muscle strength and the effects of resistance exercise. However, there is a lack of reliable evaluation methods for muscle activation due to measurement errors from frequent muscle movements and variations of sensor positions on the body. The present study aims to propose two reliable indicators for evaluating muscle activation; one is by using surface electromyography (sEMG) signals (Heinonen et al., 2012), and the other is by utilizing Detection of Muscle Activation (DoMA; Son et al., 2018). **Method** There were two types of experiments. The first experiment was to examine upper limbic muscle activation based on the hand resistance exercise. Participants (N=3; 29-31 aged) did hand exercises using a hand gripper with three levels of strength (easy, moderate, hard) for 60s at each level. The second experiment was about thigh muscle activation to measure lower leg muscle activation based on the resistance walking exercise. The other participants (N=1; 31 aged) walked on the treadmill after wearing a wearable robot (GEMS-H; Lee et al., 2020) with resistance walking mode at the maximum resistance level for 30s. We got signals on muscle activation from sEMG and DoMA at the same time during experimental period. **Results and Discussion** There are commonalities and differences between signals from sEMG and signals from DoMA in the two experiments. The sEMG seems to measure whether muscle becomes activated or not, and DoMA seems to detect how many the muscle moved. Although there are variations depending on the location of the measured muscles, the results of sEMG and DoMA analyses suggest reliable indicators that can evaluate the activation of the closest muscles of each sensor.

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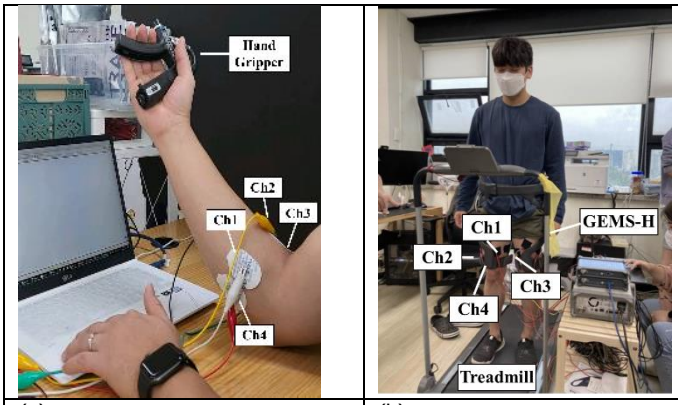

(a) (b)

Two types of resistance exercise:
(a) Hand gripper exercise,
(b) Resistance walking exercise with GEMS-H

Keywords: effect of exercise, sEMG signals, hand gripper, GEMS-H, resistance exercise
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