조선소에서의 워크플로우에 기반한 작업자 이동성 모델

Dat Van Anh Duong, 윤석훈*

울산대학교

mrdvad11@gmaill.com, *seokhoonyoon@ulsan.ac.kr

A Workflow-based Mobility Model of Workers in Shipyards

Dat Van Anh Duong, Seokhoon Yoon*
Ulsan Univ.

Abstract

In shipyards, the movements of workers greatly affect the performance of wireless networks and IoT services. To fully validate such services and networks, worker's movements should be considered. A lot of human movement models have been studied but most of them focus on the daily movements of people. That cannot reflect the worker's movements in shipyards. Therefore, we propose a new mobility model called the workflow-based mobility model of workers in shipyards (WMS). To fully reflect the worker's movements, we consider workflow of workers for movement generation. First, workers are classified into types. Workers in a type have similar movement characteristics (e.g., pause time and movement speed). Then, a type is divided into teams. Workers of a team have the same workflow and workplace. Workers move based on their workflow.

Ⅰ. Introduction

There are a lot of automatic systems, IoT services, and wireless networks [1] in shipyards. Before applying those systems and services in real factories, they should be simulated and evaluated. Worker movement patterns are a key component and greatly affect the performance of such systems and services. However, collecting real-life worker's movements is costly and highly time consuming. Therefore, synthetic models are studied for generating human movements.

A lot of human mobility models are proposed [2-3]. In those models, human movement characteristics are studied to capture daily movements of people in a very large scale such as a citywide and countrywide. For instance, urban context aware mobility model [2] has considered human movements in urban areas, and the movement characteristics such as flights and pause times are also taken into account. In a social relationship-aware human mobility model [3], the characteristics such as flights, pause time, and radius of gyrations are considered, and the social relationships among people are also studied for human movement generation. However, movements of workers in shipyards have unique movement characteristics such as movement speed, pause time. In additional, the real contexts of workers in shipyards are not considered in those studies. Therefore, they could not fully represent the movements of workers in shipyards.

To fully reflect the realistic of worker movement in shipyards, we propose a new mobility model called the workflow-based mobility model of workers in shipyards (WMS). In WMS, the real contexts of workers in a shipyard are considered. Workers move based on their workflow. Specifically, workers are classified into multiple types. In a type, workers have the similar of movement characteristics such as movement speed and pause time. That is true with the real context. For instance, workers, who drive forklift trucks, have similar movement speed, and pause time. In a type, workers are divided into teams. Workers in a team have the same workplace and workflow. Workers move based on their workflow in workplace.

Ⅱ. The Workflow-based Mobility Model of Workers in Shipyards

In this section, the mobility model of workers in shipyards is described.

Specifically, a shipyard layout [4] is considered as the movement area of workers. The shipyard includes multiple subareas. In this work, the movement of workers is focused on a subarea (i.e., unit assembly (UA)). UA is divided into 32 blocks and each block is partitioned into 20 units.

Workers in UA are classified in multiple types. We consider that workers in a type do the same job. For example, workers in type 1 are workers, who drive forklift trucks. Workers in type 2 welds and cuts steel. Workers in type 3 paints ships. Workers in a type will have similar movement speed and pause time. Then, workers in a type are divided into teams. In a day, each team randomly select a block in UA to work. Workers in the team will move in that block in the day.

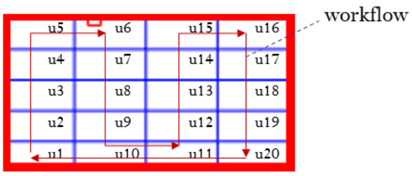

Figure 1. A sample of workflow in a block

After selecting a block to work in the day, workers in the team randomly select a unit to start their work. We suppose that the workflow in the selected block is shown in Figure 1. In the real context, we see that after end of the pause time (i.e., finished the work) at current unit, a worker will have a high probability to visit the next unit in the workflow and a low probability to visit other units. For example, worker 1 has finished the work at unit u1. To reflect the real context, the probability that workers visit the next unit (unit u2) in workflow is defined as p_{next}. p_{next} is set to a high value (e.g., p_{next} = 0.9). We define the set of neighbor units of unit u1 as S_{u1} = {u9; u10} and n^{u1} is the number of neighbor units of unit u1. The probability that worker 1 visits a unit i in S_{u1} is defined as p_i. p_i is calculated as:

$$p_i = \frac{(1 - p_{next})}{n^{u1}} \quad (1)$$

In selected unit, worker 1 randomly chooses a position to visit.

Ⅲ. Simulation Result

In this work, Matlab was used to simulate MWS. Based on the human movement characteristics in real mobility traces [5-6], the pause time of workers is set to follow a truncated power-law distribution with a range of values from 0.5 to 227 minutes and the movement speed follows a log normal distribution, *Lognormal(−0.684, 0.97²)*. We generate movements of 200 workers for 70 hours.

To validate the distributions of workers movement characteristics obtained from MWS, the akaike information criterion (AIC) was used. Table 1 presents the results from AIC between a truncated power-law distribution (denoted as Pow), a normal distribution (denoted as Nor), a lognormal distribution (denoted as Log) over the pause time and the movement speed. The obtained results show that movement characteristics from WMS are the same as the real traces. Specifically, the movement speed fits better to a lognormal distribution and the pause time follows truncated a power-law distribution.

Table 1. Result form AIC for pause time and speed

	Pause time	Speed
Selected model by AIC	Pow	Log

Ⅲ. Conclusion

In this work, we proposed a workflow-based mobility model of workers in shipyards. Based on real contexts of workers in shipyard, workers are classified into types. The workers in a type have the similar movement characteristics. Then, each type is divided into teams. Workers in a team have the same workplace and workflow. Our mobility model can fully reflect the realistic of worker's movements in shipyards.

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