Study on smart garbage bin system for understanding household garbage disposal and contents estimation

Name: Eunice Likotiko
Laboratory' s name: Ubiquitous Computing Systems
Supervisor' s name: Prof. Keiichi Yasumoto

Abstract
Daily in homes, there will always be a lot of garbage produced. However, the type of garbage contents and the amount varies with the family structure, including eating and cooking behaviours. Again, garbage separation by the person who disposes of garbage has been widely accepted as ethical behaviour. Although, the existing IoT-based smart garbage systems and the classification of garbage from images by artificial intelligence have gained positive achievements. Yet, most current IoT garbage systems are unfriendly in learning garbage growth behaviour and identifying the type of garbage contents disposed of daily by households. Moreover, they provide unsatisfactory garbage categories for reasonable practices of household garbage separation. Therefore, an enhanced IoT-based garbage management system and substitute automation tools for classification are necessary to improve existing garbage management systems. In this dissertation, we present a smart garbage bin system, SGBS in short, to realize its benefits on three challenges: (1) How to predict garbage growth behaviour for a single house?; (2) How to understand household garbage disposal behaviour and identify the type of garbage contents?; and (3) How to substantially improve the automation of garbage classification? Regarding the three challenges, first, we designed and developed a smart garbage bin system, SGBS, embedded with ToF (time of flight) and load cell sensors to track the amount of garbage, and DHT22 (temperature and humidity) and MQ135 gas sensors to monitor the running state of the smart garbage bin. Using a Wi-Fi gateway, data are stored in the cloud. Then, to evaluate the first challenge, we experimented with the SGBS in a student laboratory. An autoregressive integrated moving average (ARIMA) model was applied, providing MAE of 5.17 cm and an SD of 0.33 cm, thus considered satisfactory accuracy on the garbage growth prediction. To examine the second challenge, we later extended our SGBS to identify the disposed of garbage contents through a smartphone installed with a garbage annotation application comprised of 4 categories of garbage contents and 10 garbage content identities, thus guiding users during garbage disposal. Afterwards, we conducted an initial experiment in three households to evaluate our approach. Our findings show that households' garbage disposal behaviour depends on the amount and contents of garbage and the routine of disposing of such garbage content. In connection with the third challenge, we first extended the initial interface of the garbage annotation application to have 8 garbage categories and 25 garbage content identities for more logical household garbage separation. Then, we deployed the designed SGBS with the extended annotation interface in five households. Eventually, we constructed a garbage content estimation model, and we confirmed that the overall result models with leave-one-house cross-validation can achieve an accuracy of 91% in kitchen waste contents, 89% in paper/softbox contents and 85% in the garbage categories for the classification tasks.