Using SenseCam images in a multimodal fusion framework for route detection and localisation

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ABSTRACT
Problem of structuring location data is solved by proposing a framework for classifying the data into often-traversed routes. It does not rely on any one source of location information, but can fuse data from multimodal localisation sources: SenseCam images, GPS data and WLAN signal strengths.

Keywords
SenseCam, Multimodal data-fusion; GPS; WLAN; image matching; MDTW; SURF

The problem of route-matching is complicated by a number of factors including the need to track users seamlessly in both indoor and outdoor environments, the need for robustness to slight deviations in the path and the user's speed taken along a route. We investigate the combined use of GPS, wireless signal strength readings (WLAN) and SenseCam image-matching to provide reliable user route matching. Whilst GPS has become synonymous with user localisation, its robustness can be called into question. Indoors, GPS signals are weak and outdoors signals can be affected by obstacles, multipath propagation and tall buildings causing serious errors in localisation; in the case of WLAN, localisation indoors is generally good but variations in the environment, such as temporary changes to building layout or weather conditions, can affect signal strength. Using image matching to determine location is an alternative technique to radio-frequency based approaches. Occlusion and changes in lighting are the main problems for this approach. Nowdays users regularly collect large amount of different types of location data. This large collection of data is potentially useless without some means of structuring the data to make it understandable and searchable. Such applications of using large amounts of location data can be of benefit to a variety of users. For example, runners may wish to know how often they take a particular route whilst jogging. In caring for the elderly, allowing a mobile device to automatically determine whether they have deviated from their normal routine can trigger a notification to their carers. In the life-logging community, route matching can add valuable structure to the months and years of recorded daily activities. A set of training data was collected simultaneously using a SenseCam , GPS device and Campaignr software installed on a N95 Nokia phone (for collecting signal strengths data). Measurements were taken on 6 selected routes within and around the Dublin City University (DCU) campus, ranging from 330m to 615m in length. The devices were synchronized and the data recording was collected at regular time intervals. Each route was traversed many times over a period of 6 weeks, yielding 30 testing and 24 training sets of data for overall. Signal strength information is considered to be 3-dimensional as the same 3 MAC addresses were discernible along each trip. GPS data is deemed to be 2-dimensional (consisting of longitude and latitude coordinates). On average, a trip consisted of approximately 30 images along the route. In order to find a similarity measure for data collected during different trips the Multidimensional Dynamic Time Warping Algorithm was employed. The algorithm uses a local distance measure to determine the similarity between two sequences. In order to classify a new trip into one of the known routes, we used a k-NN (nearest neighbour) classifier. This simple classifier can account for the large variability of the localisation sources, as well as being able to easily accommodate new trip examples for online training. To fuse the localisation data from our three sources, we computed a weighted linear combination of the distance matrices of the sources. These matrices were suitably weighted and then added. Using a training set of 24 trips we identified a set of optimal weights for each combination of sources using an exhaustive grid-search. The weights were selected such that sum is equal to 1 and the classification accuracy on the training set was maximised. We evaluated the classification performance on 30 separate testing trips. Preliminary results of combining three complementary sources of data for classifying trips from localisation data are presented. By fusing GPS, wireless signal strength readings and image-based matching, we achieve better performance than any individual/combined modality.

In this work, we presented preliminary results of combining three complementary sources of data for classifying trips from localisation data. By fusing GPS, wireless signal strength readings and image-based matching, we achieve better performance than any individual/combined modality. Future work will investigate other fusion methods, such as adaptive confidence-based weighting, more sophisticated classiers (such as SVMs) and evaluating performance on indoor routes where GPS is expected to perform poorly and WLAN to improve.

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