Group Activity Recognition using Mobile Devices

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Abstract. Group activities are more than the sum of the activities of the individuals in them, but are rather generated by those activities and interactions between group members. This thesis proposes group activity recognition (GAR) using collaborative mobile user devices for sensing, processing and recognition. The contribution is a thorough evaluation of a method for approaching a completely novel problem.

1 Motivation

Multi-user activity recognition (MUAR) is an established field of research and focuses on recognizing activities performed in parallel by multiple users, including concurrent or conflicting activities [8]. Video cameras have been shown to provide good results, capturing multiple users, activities and the context at once [2]. Using cameras, however, requires a priori instrumentation and infrastructure, which presents a strong disadvantage [5]. However, other approaches use mobile wearable devices for sensing which are ubiquitously available [8].

Group activities refer to the group as an entity, which is an abstract concept with respect to the activities of the individuals in the group. The group must be observed as if it where an entity, and each individual a composite part [4]. Groups exhibit emergent behavior, generated by single-user activities and interactions between users, making GAR and MUAR two distinct fields. Furthermore, research has suggested that MUAR methods may not be optimal for GAR [4]. A symbiotic area of research is recognition of group formation and affiliation, where mobile sensors have also been proven effective [9]. This research is however not directly concerned with *what* a group is doing, as much as *how*.

The thesis of this dissertation is that mobile devices of group members, can collaboratively estimate emergent group behavior, where each device can only measure local activities and interactions. The contribution of this dissertation is a method to recognize group activities as shown in Fig. 1. The method will be evaluated in terms of algorithmic correctness, resistance to failures, convergence time, complexity, and the dynamic nature of the activities being recognized. Currently, the author is not aware of any other research into GAR using wearable sensors, therefore this approach cannot be compared with other established methods. Fig. 2 shows the structure of the proposed doctoral thesis, where complexity and scale of the algorithms and experiments are increased over time.

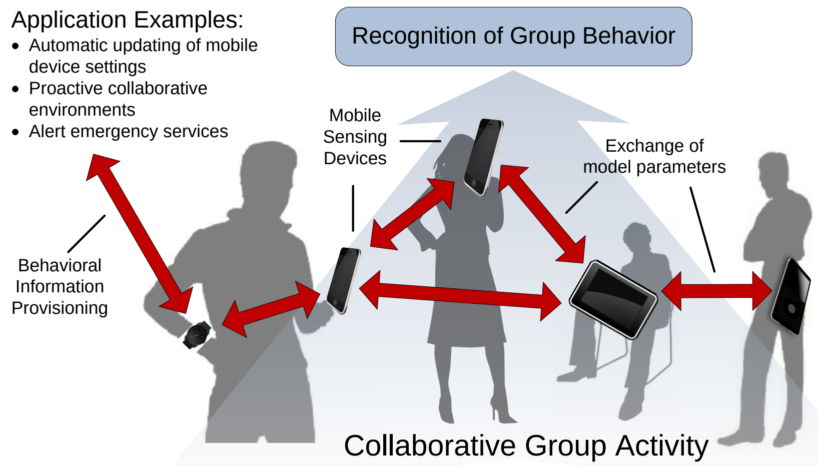


Fig. 1. Collaborative Group Activity Recognition using Mobile Sensing Devices

2 Algorithmic Approach

Recognition of group activities using a distributed sensing platform is inherently a data fusion task, where distributed measurements must somehow be fused into a single group activity [4]. A fully distributed approach must be resistant to node failures and must fuse the sensory measurements across all nodes into activities, but fusion is possible at many different abstraction levels. The approach taken is based on distributed probabilistic inference (DPI) using belief propagation (BP). The methods used for comparison are shown in Fig. 3, where first signal feature information from all nodes is processed by a dedicated node (a), or abstract activity information (b), or (c) a fully distributed approach (DPI). The concept of DPI using PB is that each node calculates its own belief about hidden variables (activities), and communicates this information to its neighbors based on a prior distribution or conformity function. DPI has been shown to work for sensor calibration in wireless sensor networks [6], but its effectiveness for HAR or GAR is unknown. Specifically, convergence time, susceptibility to node and link failures, and recognition of dynamic events are being evaluated.

As with context (activity) prediction [7], different abstraction levels have different advantages and drawbacks, in this case energy consumption versus recognition accuracy. An investigation of different abstraction levels for GAR [4] using standard centralized recognition algorithms indicated that fusing raw sensor data is energy expensive with no advantage over using sensor signal features, both of which represent a maximum in terms of recognition. Abstracting

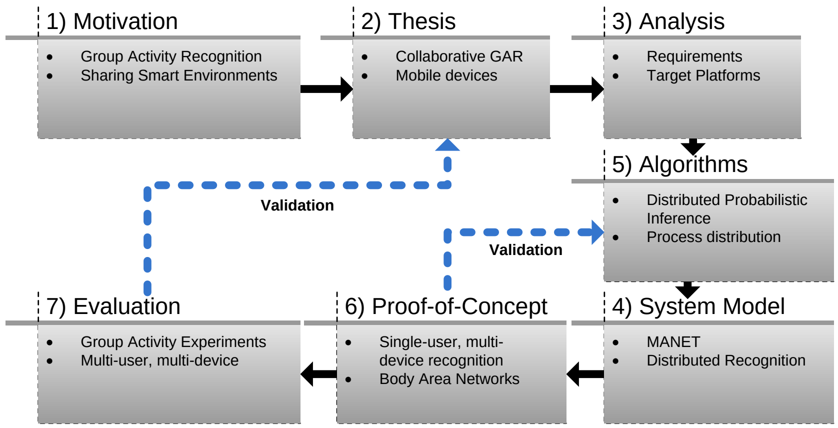


Fig. 2. Structure and Composition of this Thesis

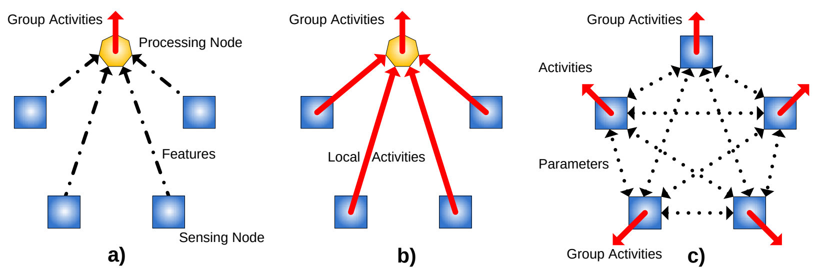


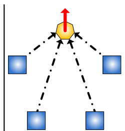
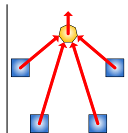
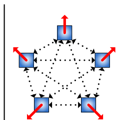
Fig. 3. Algorithmic Approaches for Evaluation of the Contribution

to single-user activities before fusion to group activities highlighted several practical difficulties, though unsupervised clustering provided promising results [4].

3 Evaluation and Conclusion

In Tab. 1 the progress of this dissertation is presented. Data sets from single-user and group activities will be artificially altered to simulate changes in parameters such as rate of change of activities, node failures, etc.. The algorithmic properties such as convergence time, recognition (compared to centralized approaches), memory and energy consumption will be evaluated. The results of these simulations will validate the algorithmic selection and implementation (see Fig. 2). A comparison between sensor data, feature data and single-user activity data for GAR has been presented in [4]. GAR using DPI experiments are in preparation, in which teams of individuals playing sports will be monitoring. In this experiment, single user activities (running, dribbling, throwing, etc.) as well as group activities (football, basketball, handball, etc.) can be labeled and recognized, evaluating distributed GAR using DPI for mobile devices in the process.

Table 1. Communication Volumes and Power Consumption Results

			
	Common HAR, Well Understood by Community [1, 3, 8]	Not Relevant for GAR	DPI for HAR in BANs, In Progress
	Research Complete [4]	Research Complete [4, 3]	Recognition of Team Sports, In Preparation

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