A Theoretical Framework for Collaborative Networked Positioning

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Abstract
We propose a theoretical framework for collaborative networked positioning, which can be applied to the location mapping for human wearable devices in the physical world as well as social connections in social networks. The framework includes three coherent mechanisms: distance and status measurement of units in a network, relative position in the network, and absolute orientation in the physical or social networked world. It is collaborative without centralized control. At-will participation and broadcast between the nodes preserves privacy and reduced communications. Relative and absolute positioning are also decoupled to increase robustness and flexibility. Such a framework once deployed can help allocate social resources and predict times of changes.

Author Keywords
Collaborative Network; Networked Positioning; Social Computing; Internet of Things.

CSS Concepts
• **Collaborative and social computing;** *Collaborative and social computing theory, concepts and paradigms*; Computer supported cooperative work

Introduction

In collaborative environments, such as social network and internet of things, location and mapping are essential for locating resources, navigating the network hierarchy, and improve communication efficiency. We propose a theoretical framework for collaborative networked positioning, which can be applied to the location mapping for human wearable devices in the physical world as well as social status mapping for human social networks in social computing. The framework includes three coherent mechanisms: distance and status measurement, relative position in the community, and absolute orientation in the physical or social world. It is collaborative without centralized control. Furthermore, at-will participation and broadcast between the nodes preserves privacy and reduced communications. Relative and absolute positioning are also decoupled to increase robustness and flexibility. Such a framework can help quantify the social network connectivity as well as physical world correlation. Therefore, people can utilize it to navigate shifting identities and networks and find support and resources, when they desire social technologies and physical location information to help.

Figure 1 shows the overview of the framework.

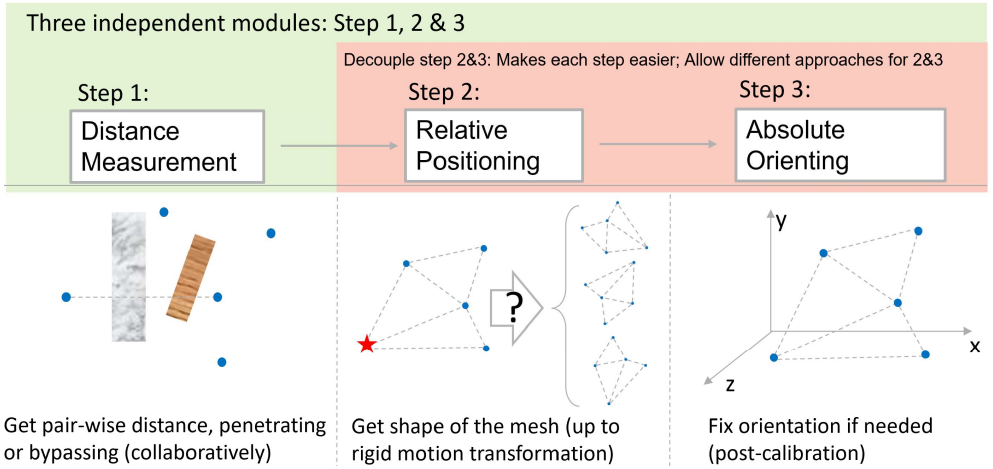

Figure 1: Overview of collaborative networked positioning.

The framework starts with a module of pair-wise distance measurements between the nodes to understand the connection degree and status, followed by decoupled relative positioning and absolute orienting of the whole network graph.

Algorithmic Flowchart

Figure 2 illustrates the overall flowchart of the algorithms of the proposed framework.

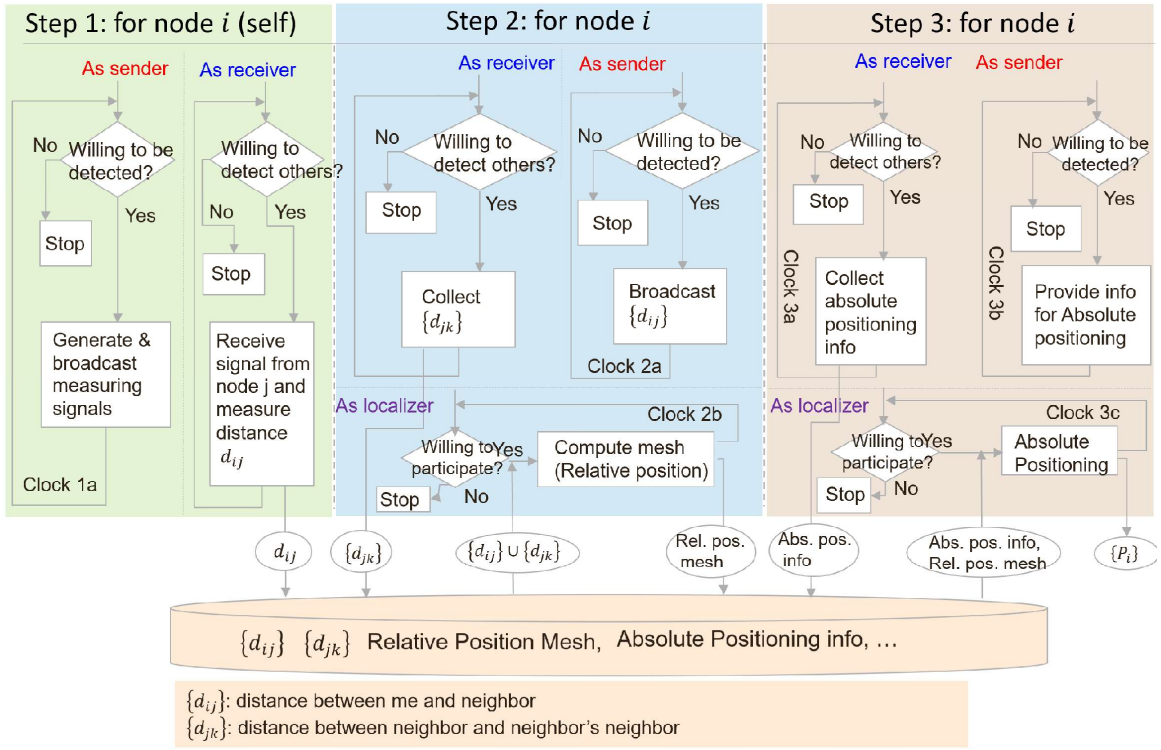

Figure 2: Flowchart and architecture of the proposed framework.

Distance Measurement

Figure 3 illustrates the protocol of network distance measurement, where participation is at will for privacy preservation. Multiple measurements, e.g. a counter of 3, are in place to improve accuracy. Such a distance can be the number of hops between the connectivity of friends in a social network.

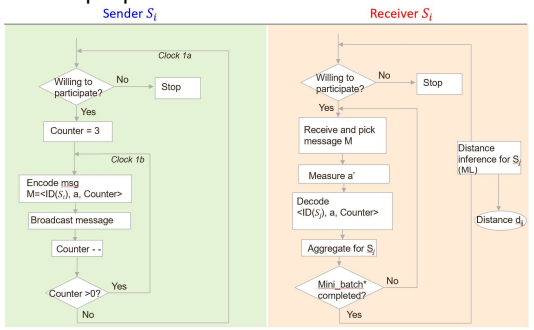

Figure 3: Protocol of network distance measurement.

The network distance measurement protocol covers a few cases as follows:
// Sender vs Receiver:
S_i: Broadcast measuring signal
R_i: Compute distance
// Sender's broadcast range varies:
From node to node ($S_i$vs S_j)
From time to time ($S_i^{t_1}$vs $S_i^{t_2}$)
// Receiver's measured neighborhood varies:
From node to node ($R_i$vs R_j)
From time to time ($R_i^{t_1}$vs $R_i^{t_2}$)

For example, between time step t1 and t2, a few cases can happen as shown in Figure 4.

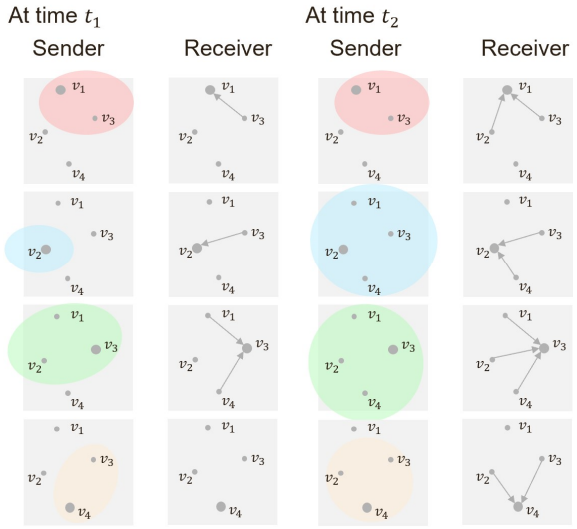

Figure 4: Varied use cases during network distance measurement.

Relative Positioning

Algorithms to conduct relative positioning is shown in Figure 5.

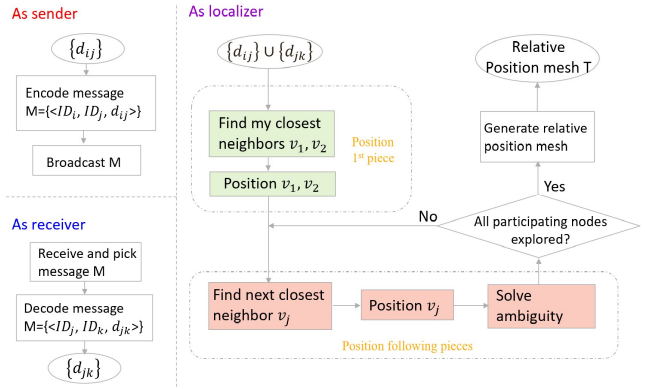

Figure 5: Relative positioning algorithms.

Generating the social or physical network graphs can be challenging. Yet, proper deduction can facilitate the graph construction for the relative positioning as shown in Figure 6.

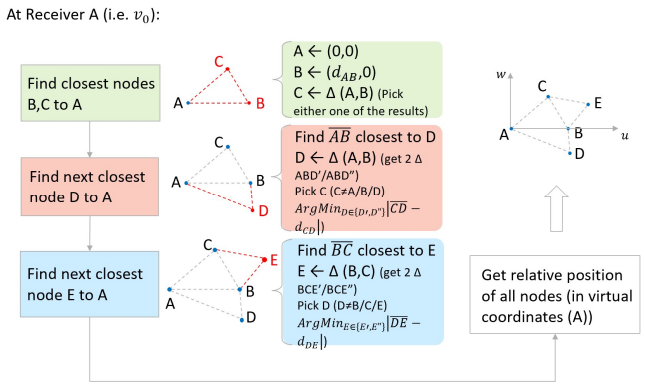

Figure 6: Example to construction relative positioning.

As a result, networked physical or social positions can be illustrated with an annotated graph as illustrated in Figure 7.

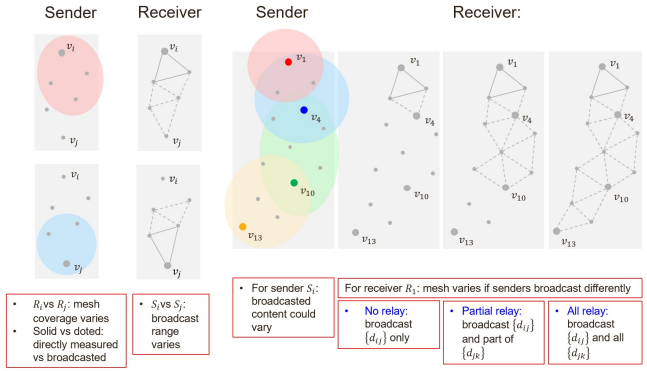

Figure 7: Example of graph construction during relative positioning.

Absolute Orientation

Lastly, absolute orientation can be implemented with three options: (1) Position matching; (2) ID Matching; (3) Image matching. Figure 8 shows the breakdown of these three options.

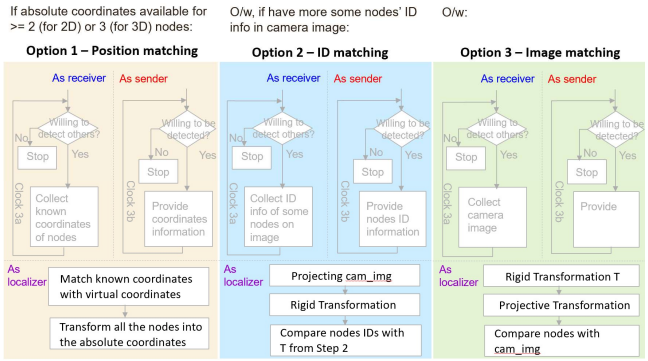

Figure 8: 3 options for absolute orientation.

As an example, Figure 9 illustrates each option during absolute orientation. Once completed, the physical or social networked graph can be utilized for resource allocation, analysis of unusual connectivity, prediction of potential emergence of life transitions, etc.

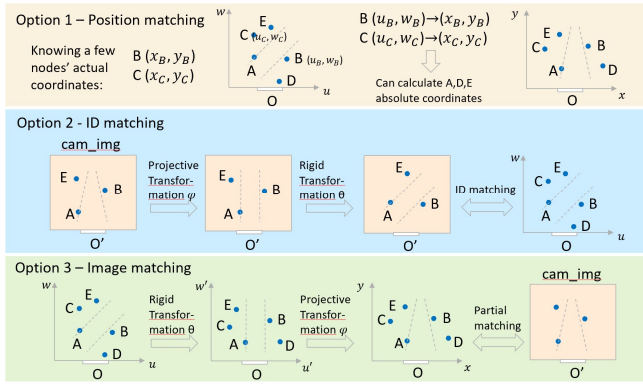

Figure 9: Examples of options in absolute orientation.

Conclusion

In this paper, we have proposed a theoretical framework for collaborative networked positioning, which can be applied to the location mapping for human wearable devices in the physical world as well as social status mapping for human social networks in social computing. The framework includes three coherent mechanisms: distance and status measurement, relative position in the community, and absolute orientation in physical or social world. Such a framework can help quantify the social network connectivity as well as physical world correlation. Therefore, people can utilize it to navigate shifting identities and networks and find support and resources,

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