Communicative Vibration:
A Graph-Theoretic Approach to Group Stability in an Online Social Network

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Social groups are complex dynamic systems – some may grow while others stagnate and die out, often interdependent with the state of other groups in the system. Recent research has attempted to predict the stability or vitality of meso-level groups using a wide variety of sociometric data, often with inconsistent results[1, 2, 3, 4]. The present study advances a new technique for characterizing group stability which we call "communicative vibration". This technique leverages graph theory to assess the energy in networked communication. Specifically, we adapt the Fruchterman-Reingold layout algorithm[5] to measure changes in a node's position over time, representative of changes to the structure and frequency of communication within the group and situated in the broader social context. We then assess the role of this dynamism in predicting relevant group-level outcomes, such as group growth and death, as well as merging of groups, and compare communicative vibration to network and group characteristics which have been used in prior studies of group vitality.

The Fruchterman-Reingold algorithm[5] is a force-directed graph layout algorithm designed with the purpose of maximizing certain aesthetic qualities of a graphic representation of a network, such as minimizing vertex and edge overlap. However, in achieving those goals, the authors created an algorithm which mimics several material properties and processes; spring or attractional forces bring connected vertices together, repulsive forces spread non-connected vertices apart, and movements of vertices in space are iterated via simulated annealing to produce a (local) maxima for vertex placement. By manipulating the strength of attractive and repulsive forces, as well as the cooling schedule for the iterative placement of nodes, we can fine tune our measurement of vibration. In this way, our measure of communicative energy in social groups reflects the use of vibration to study material strength in physical sciences[6].

We utilize this procedure to study data from a Massively Multiplayer Online Role-Playing Game (MMORPG), which we refer to as "Game X". Game X allows users to join explicit groups, called guilds, which allow players to coordinate their in-game actions, including combat with other players or guilds, and pool resources. We construct weighted and directed networks using 730 days of in-game communication between players. We then calculate communicative vibration in three ways: as movement of networked players, as the movement of the centroid of the small group, and as changes in the distance of a group's members from its centroid between each time step in the data. These measures are then included as a guild-level feature in a variety of machine learning frameworks (e.g., random forests, naïve Bayes, etc.) to predict group events. These events include the dissolution of the group, the merging of one group with another, and the formation of new groups. Communicative vibration is compared against other group features, such as age and diversity of in-game skills [1]. We conclude with a discussion of the computational feasibility in other dynamic networked contexts, the sensitivity of the layout parameters, and the implications of this method for studies of small group lifecycles.

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