# Designing Expressive Motions for a Robot Requesting Help: Attributions and Task Performance

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## I. Introduction

To effectively share spaces, a robot operating in human environment needs to learn the relevant social conventions. For example, a robot that dashes through doorways or collides into people in its way would likely be more offensive and appear to be less competent than one that knew how to politely wait its turn or indicate to someone that they should let it pass. When such a robot needs help from people to complete its tasks, such social capabilities become even more critical. A robot's ability to make use of social norms and relevant social cues is likely to affect whether people will volunteer to help and whether they understand its request.

Humans are well versed in social behaviors, as they are an essential part of how we communicate, therefore we make impressions very rapidly. Thus, a robot's motion patterns will impact our assessment of its capability and likability even before it vocalizes (should it speak at all). A rapid approach might make its interaction partners feel intimidated, or not orienting directly toward someone might make them feel unimportant; both making it less likely that they would respond to its request.

Our goal is to understand what different sets of motion characteristics communicate about robot state, and how these state communications affect task performance. To do this, we outline our design for a series of motion behaviors in which a simple 3-DOF mobile robot requests help from various people in its environment, then we describe our approach for evaluating these varied motion patterns with people. Our application is a robot that asks for help pressing the button of an elevator (it cannot press the button itself). So, for example, the robot might appear to be more or less hurried, more or less focused on the person it is addressing, and more or less aggressive because of its gaze pattern and manner of approach.

This extended abstract explores the design considerations for (1) generating such sets of motion characteristics from the Laban Effort System and applying them to a real-world robot system and (2) tracking how the contrasting motion implementations affect human response. Our future results will evaluate both the attributions people have toward the robot (e.g., polite or annoying, human-like or mechanical) and how these affect its ability to get help (e.g. average time to complete task).

## II. Designing Expressive Motions

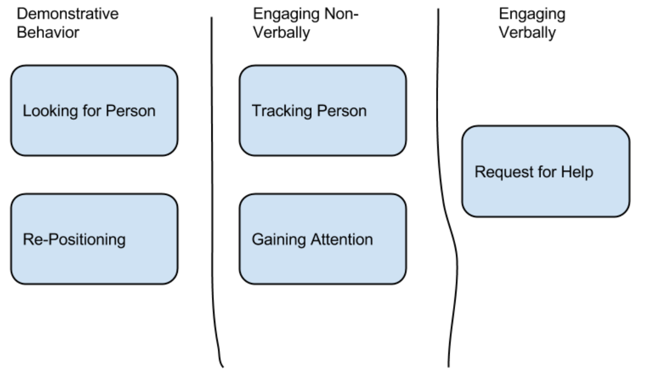
Previous work demonstrates that people will ascribe emotions and intention to robots exhibiting characteristic or sequentially recognizable motions [10][13][14]. Wizard-of-Oz experiments with an 'emotive' stick [2] found its motion to impact social attributions of personhood or machine. A study with single-axis door [3] confirmed those findings. After the door opened slightly then closed, one subject reported that it indicated that the door saw them, judged them and decided not to let them in.

The motion characteristics we use are motivated by the Laban Effort System [5], a part of Laban Movement Analysis, a notation for dance choreography. The Laban Efforts are commonly taught to actors to help imbue actions with dynamic characteristics that convey different associations of state, in other words, the 'how' of a motion. In contrast to a psychological approach to acting, it is a physical theater technique intended to communicate the actor's motivation. The efforts include Time (sudden vs. sustained), Weight (heavy vs. light), Space (direct vs. indirect), and Flow (bound vs. unbound), outlined below.

| Effort Vector | 1st Polarity | 2nd Polarity |
|---|---|---|
| ***Time:*** *attitude toward time* | Sudden (abrupt) | Sustained (gradual) |
| ***Weight:*** *force* | Strong (powerful) | Light (delicate) |
| ***Space:*** *attitude toward target* | Direct (single-focus) | Indirect (multi-focus) |
| ***Flow:*** restriction | Bound (constrained) | Free (unconstrained) |

Laban provides the dramaturgical motion approaches most frequently referenced in robotics and human-tracking work [1][6][7][9][11]. The Effort System does not require humanoid form. Researchers utilized Laban trained actors to create readable trajectories for flying robots [12]. In previous work, we have populated quantitative features representing the Laban Efforts [4], e.g. weight can be represented by acceleration pattern, space by the robot's orientation.

In this work, we apply Laban Efforts characteristics to motion design for a specific robot task scenario: asking for help pressing the button at the elevator. We are implementing software that overlays the desired motion characteristics to each step of the request for help (see diagram). While looking for someone, a direct robot might select a hallway and stare intently, then look to the next, whereas an indirect robot might look somewhere else altogether. Better understanding the impact of these motion features will enable us to design contextualized robot motions. A robot monitoring a parking garage in the middle of the night should convey different sets of motion characteristics than one delivering juice boxes at a preschool. If we were to apply




the Laban Efforts, we might have the parking lot security robot react abruptly (suddenly) to unexpected sounds and ambulate with strength, high sense of direction and a bound flow to convey a sense of aggression, high attention and professionalism. The nursery school service robot should be much more easy going (sustained, light, perhaps unbound), although its focus might still be directed to make clear to the children that the juice boxes it carries are for them.

## III. Evaluating Expressive Motions

Following standard practice for a social robotics project, we evaluate the effectiveness of our robot behavioral design with the humans that that design is meant to impact. Validation will include 1) tracking the effect of expressive motion on task performance across a variety of robot states and 2) running user studies that characterize the attributions people make toward the robot.

The robot we use is called the CoBot, an omnidirectional mobile robot, which has no arms (see photo). CoBot can autonomously navigate including traveling along corridors, traversing open spaces, and riding elevators. CoBot's current tasks include meeting someone at an elevator to take them to a destination, delivering a message, and picking up or dropping off objects. It has no arms, so along the way, it must ask for help from people - like asking people to press the elevator buttons so that it can make it to another floor of the building.

Because the robot has been deployed and operational for the last three years, we have ethnographic feedback from both the design team and people with whom the robot shares the hallways. For example, those with office doors near the elevator sometimes get tired of hearing the robot asking people if they could press the elevator button. The robot's use of motion cues before speech could reduce the frequency of those requests, by weeding out those unlikely to stop. The ability of the robot to demonstrate via, for example, its orientation, that it is seeking to engage someone and aware that someone is passing may also make bystanders more willing to help.

To explore possible attributions people make towards the robot given different enactments of the motion, we will explore the extremes of the four Laban Effort scales, and their unique combinations (twenty-four). The impact of varying each scale might be consistent irrespective of the other channels, e.g., perhaps directed gaze (Space) always makes the robot seem more intent on its task as compared to averted gaze or looking between multiple people. In other cases, particular combinations of channels might result in contrasting communications of robot state, e.g., delayed reaction in turning toward someone (Time) with high force in its accelerations (Weight) might make the robot seem disinterested, whereas a delayed reaction with low force might make it seem relaxed. We hypothesize that the attribution findings will help predict how often and rapidly people help the robot.

We will evaluate the robot's task performance as a result of exhibiting expressive motion (e.g., will the robot be able to get help faster, with fewer people declining). We will also run a user study to collect their attributions and analyze their behavioral and verbal responses to the system. As long as the robot's requests are effective, it can operate with a simple mechanical design, e.g. it is not required to have an articulated robot arm. Such findings could extend to other collaborative robots. By utilizing a real-world system, we will assess the effect of incorporating expressive motion into certain robot behavior systems. We will also better understand how certain expressive motions can be impactful or counterproductive to particular robot tasks.

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