A Robot Acting Partner

David V. Lu, Chris Wilson, Annamaria Pileggi and William D. Smart

***Abstract*— In this paper, we describe our initial experiences using a mobile robot as a teaching aid in a stage movement class, taught in the Performing Arts Department at Washington University in St. Louis. The robot participated in a number of exercises, intended to teach the fundamentals of movement, and interacted closely with college-age human acting students. We describe these exercises, what they are designed to teach the students, and discuss how using a robot as a teaching aid can enhance the students' experience. We describe two classes in which a robot participated, one with a tele-operated robot and one with a fully autonomous robot. We then discuss the students' reaction to the robots, our evaluation of the system's success and the larger context of the experience.**

I. INTRODUCTION

Acting is a craft in which one explores communication in varying scenarios, involving people with conflicting needs and goals. Teachers of acting initially train students to become more aware of the verbal and physical effects they have on one another. This heightened awareness is a necessary first step in effectively "acting" on another person to obtain some goal or objective [1].

This physical awareness is often taught through a series of exercises, where students first learn to act without intent, simply responding to the situation around them. This is difficult for beginning students, since it is hard to discard *all* intent from one's movements. However, this task is much easier for a mobile robot. Autonomous robots have no intent, and the lack of body language or facial expressions through which motive can be inferred easily divorces them from any perceived intent. These qualities make a mobile robot an ideal acting partner in these awareness exercises.

In this paper, we describe our experiences with mobile robots in a movement class in the Performing Arts Department at Washington University in St. Louis. We describe the specific exercises performed in the class, and what the robot did in those exercises to help teach the students. We discuss the results of this deployment, and explain why we consider it to be a success. Finally, we describe our future plans, and how we can make the robot an even better teacher.

A. Related Work

Although the word "robot" itself first appeared in the context of a stage play [2], only recently have robots appeared in live theatrical performances, often as a side-project of robotics researchers. Initially, robot theatre was dominated by robot-only performances. The first live work that we are aware of is by Ullanta Performance Robotics, a group of Brandeis (and later USC) graduate students who staged a small number of plays using an all-robot cast [3]. Wurst [4] created three small robots to perform a highly stylized improvisational piece called "The Lazzo of the Statue", in which one robot pretends to be a statue that moves when the other robot actors' backs are turned. Bruce et al. [5] used two autonomous robots to perform comedic improvised pieces.

More recently, robots have been integrated into performances with human actors as well. Hoffman et al. [6] described a set of performance pieces involving a robotic desk lamp and a single human actor. Ishiguro and his collaborators produced a play, recently performed at HRI2010, with two human actors and two Wakamaru robots, exploring the relationship between humans and robots [7]. In more traditional theatrical settings, Les Freres Corbusier theatre company mounted a well-reviewed production of *Heddatron* [8], in which five robots kidnap a Michigan housewife and force her to take part in their production of the Ibsen play *Hedda Gabler*. This piece is typical of "real" theatrical appearances of robots, in that the robots were essentially self-propelled props, used for comedic effect [9]. *A Midsummer Night's Dream* has provided inspiration for a number of robot-theatre collaborations (possibly due to its themes of different worlds colliding). Duncan et al. [10] employed robot helicopters to act as flying faries in a mostly human production of the show. Also, the UPenn GRASP Lab put on a series of pieces with humans and robots inspired by the same play [11].

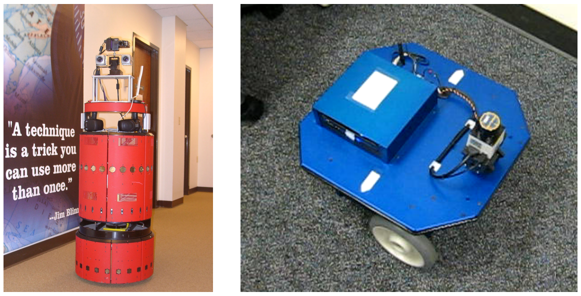
Less traditional performance pieces with robotic elements, such as Breazeal's "Public Anemone" [12] are also appearing more and more frequently at conference venues such as SIGGRAPH.

On the other hand, there are a number of situations where robots are used for teaching tasks. The RUBI Project used a robot to teach children aged 18 to 24 months vocabulary skills [13], and robots in Korea help sixth graders to learn proper English pronunciation [14]. Robots are also being used to help guide children with Autism Spectrum Disorders in developing basic social skills [15] [16].

Despite numerous examples of robots being used in performances, we are not aware of any previous work using robots in a teaching setting for the performing arts. Furthermore, most previous work where robots assume the role of teachers focuses on the children or those with developmental challenges; we are unaware of any prior work where a robot is used to teach adults, much less teaching a complex skill like acting.

Lu, Wilson and Smart are with the Department of Computer Science and Engineering, Washington University, St. Louis, Missouri, 63130 davidlu@wustl.edu, ccw1@cse.wustl.edu, wds@cse.wustl.edu

Pileggi is with the Performing Arts Department at Washington University apileggi@wustl.edu



(a) The iRobot B21r. (b) The Videre Design Erratic.

Fig. 1. The robots used in this work.

B. The Robots

Two robots were used in this work: an iRobot B21r (figure 1(a)) for the tele-operated system, and a Videre Design Erratic (figure 1(b)) for the autonomous system.

Both robots have two degree-of-freedom movement (rotation and translation), and a scanning Hokuyo laser range-finder capable of measuring distances to objects in the world. The B21r also has a number of other sensors: sonar, IR, and video. Both systems have Intel Pentium Duo-class computer systems, and communicate with the world over an 802.11g wireless link. The B21r stands approximately 1.2m tall "at the shoulder", and the Erratic is roughly 20cm tall.

In the tele-operated demonstration (section III-A) none of the B21r's on-board sensors were used. In the autonomous demonstration (section III-B), the laser range-finder was used.

II. Viewpoints

Viewpoints is an improvisational acting exercise originally developed by the dance choreographer Mary Overlie, and later adapted for stage actors by Bogart and Landau [1]. The exercise is designed to train students' awareness of their fellow actors and of the physical space that they are in, so that they can act responsively to one another in their environment. Students move about a large open space, performing unscripted movements, reacting to the actions of their fellow actors, and to the physical characteristics of the space. Actors with a good awareness of their environment respond more impulsively to situations on stage and, consequently, give better, more believable performances.

In acting terms, participants in the exercise explore space and time through movement. The impulses to move and explore are derived from different categories of environmental stimulus, called Viewpoints. The nine physical viewpoints are *architecture*, *shape*, *gesture*, *floor pattern*, *spatial relationship*, *repetition*, *tempo*, *duration*, and *kinesthetic response*. A participant may use any of these elements, as well as the movements of the other participants, to influence and guide their own movement.

Consider the following example of an interaction during the Viewpoints exercise. Two actors, A and B, are in a space together. Actor A notices some lines on the floor, and starts to follow them. Actor B sees this, and decides to mirror actor A, moving backwards and more slowly. Actor A then decides to make a gesture of abruptly checking the time (by looking at her left wrist, as if to check a wristwatch) while continuing to follow the lines on the floor. Actor B then stops mirroring A, crouches down, and slaps the floor loudly. Actor A jumps at this sound, while B continues to slap the floor, developing a simple rhythm. In our example, the actors use several Viewpoints: Actor A used *architecture* when following the lines on the floor and then *gesture* (checking the time), *tempo* (checking the time abruptly), and *kinesthetic response* (responding to the slapping noise). Actor B responded to A's work and used *tempo* (moving more slowly) and *repetition* (slapping the floor rhythmically).

It is easy to construe this example simply as a set of random movements in the space, but once they are deconstructed into a set of responses to the Viewpoints in the environment, they emerge as a clear set of actions and reactions. Actors move in response to the characteristics of the space and the movements of the other actors in time. Developing the skill of reactively responding to the (often unpredictable) actions of the other actors is one of the central aspects of the exercise. Compared to other acting methods like that of Stanislavski [17], which focus on finding specific emotions for every moment, Viewpoints is about finding true spontaneous reactions to the situation.

The goal is to perform these actions without an overt agenda (i.e. not trying to play a pre-conceived role). Actors in the exercise are encouraged to respond to their surroundings confidently, without hesitation, and without consciously thinking about the response. Two of the common pitfalls that novice actors fall into are coming to the exercise with a pre-planned agenda ("I'm going to be energetic today!"), and reading an agenda into another actor's actions ("She looks like she's escaping from something, so I'll follow her."). This causes the actor to choose actions that are not completely based on his surroundings but, rather, on some notion of what the "right" action for the role is. Failing to truly react to the environment on stage leads to a forced, stilted performance.

Since the essence of Viewpoints is to explore motion without an agenda, a mobile robot is an excellent teaching tool and acting partner. If the robot behaves according to a set of reactive rules, it has no intent, other than that implicit in the rules. The lack of body language and expression makes it hard for the actors to infer intent, whether it exists or not, in the way that they can do with other humans. In acting terms, this represents "pure movement", the ultimate goal of the Viewpoints exercise.

III. Participation in Movement Classes

The robots participated in two movement classes in the Performing Arts Department at Washington University in St. Louis. One class was a meeting of "Fundamentals of Movement", taught by Pileggi, containing approximately 20 college-age students with varying levels of experience. The other was a smaller group of four experienced students meeting outside of a formal class to refine their technique, again under Pileggi's direction.

In both classes, students were briefly introduced to the robot as "an expert in Viewpoints" before it started moving, and were told to interact with it in the same way that they interacted with their fellow actors. No technical details of the robot were given. When asked, none in the class admitted to any prior experience with robots.

A. Demonstration 1: Tele-operation

In the first demonstration, approximately 20 students in the "Fundamentals of Movement" class performed a simplified version of Viewpoints, called the Flow, with the robot as part of the group (figure 2). In the Flow, the actors are limited in their movement choices to start/stop, change direction, follow another actor, explore the space in-between (interact physically with another actor, at a distance), or explore tempo (vary movement speed).

1) Methodology: The robot was tele-operated from a control booth overlooking the room, by an experienced actor familiar with the Viewpoints exercise. No sensors on the robot were used, and the tele-operator had direct control over the direction and speed of the robot through a standard gamepad interface. In this setting, the tele-operator essentially used the robot as a proxy for his own body, observing it from a third-party vantage point. The robot acted as a mask for the tele-operator, removing any body language he might have exhibited had he been taking part in the exercise physically. The tele-operator also subjectively evaluated the reactions of the students to the movements of the robot.

The tele-operator caused the robot to seem to react to the humans around it, by performing the movements allowed in the Flow. In addition to initiating its own sequences of movement, it would follow actors, react to their movements (by starting and stopping), and vary its speed according to the actors around it. The students were not explicitly told that the robot was being tele-operated, although they could see the human operator sitting in the control booth above the room.

The exercise lasted approximately ten minutes, after which the students were interviewed informally as a group. No script was used for this interview, and the questions were intended to get a subjective evaluation of the students' comfort with the robot, rather than a quantitative measure of its effectiveness.

2) Evaluation: When asked "Were you comfortable with the robot being in the class?", several students admitted to being initially apprehensive about it, and purposefully staying out of its way. The main reason for this unease was an inability to predict what the robot was going to do next. We interpret this as a validation of our claim that the robot is a good tool for Viewpoints. To predict someone's future movements, the actors must know the other's intent. If they cannot predict actions, then they are forced to respond only to the actual action the other did, not what they thought the other would do, reinforcing the entire point of the Viewpoints exercise.

When asked "Did you become more comfortable with the robot as the exercise proceeded?", all of the students who voiced unease previously answered in the affirmative. The students claimed that, once they saw the robot obeying the rules of the exercise, they were able to relax, and try to treat it as another member of the class. This is backed up by observation from the control booth. At the start of the exercise, students tended to give the robot a wide berth, never approaching closer than an arms-length from it. By the end of the exercise, some of the students were interacting with the robot in close proximity, to the point where safe tele-operation was sometimes difficult.

3) Discussion: In this demonstration, the robot was tele-operated using a standard gamepad controller, and had no autonomy. The operator was an accomplished actor, with extensive Viewpoints experience. This raises the question of whether or not the robot was truly "without intent". Was the intent of the operator transferred through the robot or, as an experienced actor, was he able to mask (or remove) this intentional action? These questions are hard, if not impossible, to answer definitively. However, we will note that the robot acts much like a mask; even if it is being controlled intentionally, this intent is much harder for the students to interpret because of the robot's lack of body language and expression. The robot does not have the characteristic "tells" of a human actor that often betray intent, such as subtle eye movements, body-weight shifts, and so on. Ironically, the thing that causes most problems in social human-robot interaction is the thing which makes the robot particularly well-suited for the Viewpoints exercise.

B. Demonstration 2: Autonomous Operation

In this demonstration, the robot interacted autonomously with a small class of four experienced actors. Again, the actors performed the Flow, but with with instructions not to use their arms or head, and to concentrate on whole-body movements about the room. This was to inspire the actors to constrain themselves to motions similar to those that the robot was capable of performing.

1) Methodology: In this demonstration, the robot was completely autonomous and operated without human intervention. The robot relied on its laser scan data and odometry to interact with the other actors and its environment. Based on the model of the space gathered from this information, the robot performed a number of simple reactive behaviors that corresponded to the Viewpoints concepts of *architecture*, *shape*, *floor pattern*, *spatial relationship* and *tempo*, and determine where the robot moved and how it moved there. Behaviors were sequenced probabilistically, based on the proximity of humans, embodying *duration* and *kinesthetic response*. The robot participated in three separate exercises with the human actors, each lasting approximately five minutes. Students were informally interviewed in a group directly afterward. Again, no script was used, and the intention was to gather subjective impressions, rather than quantifiable data.

2) Evaluation: As with the earlier demonstration, when asked "Were you comfortable with the robot being in the

Fig. 2. The B21r taking part in a Viewpoints exercise in the “Fundamentals of Movement” class at Washington University.

class?”, students were initially apprehensive, but this apprehension diminished with experience of working with the robot. When asked “What did you think of it as an acting partner?”, one student remarked that it was had “…such different movement than what we’re used to.” However, this was seen by the students as a positive thing, since it forced them to react to the robot in the spirit of the exercise, and made them unable to predict what it would do next. The robot was also described as being “more precise [in its movements] than people normally are”, another quality that Viewpoints is designed to train.

The students all attributed some degree of agency to the robot, often referring to it as “he”. One student attributed qualities of an actor trained in Viewpoints: “he was very there, and very present”. Again, we take this as an indication of success; the students refer to the robot in the same way that they refer to another actor, and they attribute the qualities of an actor trained in Viewpoints to it.

When asked “Did you trust the robot?”, the students all claimed that, after a little initial uncertainty, that they did. One noted that “It’s without thoughts, [so] I’m not worried about what he’s going to do next.” Another said, “We have our own things that we’re working on, but he doesn’t, so I trust him and [that makes the exercise] a little more fun. He’s just reacting. [It’s] beautiful simplicity.” This trust is interesting, given the stated lack of predictability of the robot. We hypothesize that the students come to trust the system once they observe it obeying the (rather strict) rules of the exercise, and that this trust is highly contextual.

The students’ movements changed over the course of the exercises. As they interacted with the robot, their own movements became more precise, starting and stopping more abruptly, and more confident, starting at full speed. This lack of hesitation is one of the goals of the exercise, but one of the hardest things for actors to master. For example, one student would, when starting to move from a standstill, rock back slightly before starting forward. After interacting with the robot over the three exercises (which does not do this), his movements from a standing start were noticeably more crisp, and without this “tell”. This leads us to speculate that it is possible to train students in proper Viewpoints technique by providing the robot as an example, despite the differences in morphology. Of course, whether or not this change in behavior is lasting is a topic for further study.

3) Discussion: Making the robot fully autonomous allows us to ensure that the robot really does move without intent, and frees us from the philosophical complications of having a human operator. The implementation of autonomous behavior is relatively straightforward, since the Viewpoints exercise if typically carried out in a large, open space with uniform overhead lighting. The human actors are the only objects in the space and are, therefore, relatively easy for the robot to detect with its laser range-finder. In some sense, this is a particularly easy task for a robot; since there is no intention in the movement, it is near impossible to do the “wrong” thing.

The robot had a number of simple reactive behaviors, corresponding to the elements of the Viewpoints exercise. Some of the behaviors were closed-loop and did not use the sensors (such as standing still or spinning in place, for example), while others were open-loop and responded to changes in the environment (stopping when close to an actor or following them, for example).

This probabilistic sequencing of actions is the foundation for controlling the robot’s interpretation of the *duration* viewpoint. The *architecture*, *shape*, *floor pattern*, *spatial relationship* and *tempo* viewpoints are all encompassed in the movements caused by the behaviors themselves, while *kinesthetic response* is achieved by the closed-loop behavior, which responds to the perceived state of the world.

Given our robot’s lack of arms and other limbs, *gesture* creates a slightly harder challenge, which was solved by having spinning and “nodding” be considered gestures. Finally, *repetition* was given a preliminary implementation by just having the robot repeat/trace paths made on the floor by other participants.

The lack of arms, generally seen as a limitation in other robot application areas, seemed to work in our favor in this setting. Since the robot was very limited in its motions, it was extremely difficult for the acting students to ascribe intent to it. This inability to decode its body language led the students to assume that it had none and, therefore, had no intention in its actions. Whether or not this is true, in a deep philosophical sense, it did improve the quality of the class.

Similarly, the movement of the robot did not precisely match the type of movements commonly seen in Viewpoints exercises. Based on the probability parameters that were set before the exercises began, the robot performed a number of actions differently than actors in the exercise had been used to. For instance, the robot tended to stay in a much more confined area, not exploring the space nearly as much as the other actors. It followed shorter paths than the actors and tended to accelerate more aggressively. While this was initially jarring for those involved in the exercise, it gave the actors additional situations to react to, thus forcing them to truly react to the robot's motions rather than rely on what they think it will do. While there are plans to change the robot's behavior slightly to make it follow the rules more closely, these differences ended up being positive features of the robot, creating a more interesting, engaging experience for the actors.

IV. Conclusions and Future Work

In this paper, we have described the use of a mobile robot as an acting partner in two movement classes taught in the Performing Arts Department of Washington University in St. Louis. Exercises in these classes are intended to teach "pure" movement, without intention, and we claim that a mobile robot is a useful teaching tool in this setting. Our initial demonstrations with both a tele-operated and an autonomous system suggest that this is the case, and that students are very receptive to the presence of a robot in the class.

The robots that we used in these classes are, of course, fundamentally limited by their morphology. They have no arms, for instance, and cannot perform gestures. However, we believe that our initial encouraging results will carry across to more sophisticated robots, allowing them to be applied to more sophisticated movement exercises. While few performing arts departments have robots of their own, many are co-located with computer science departments that do. We firmly believe that, as collaborations between these disparate fields start to become more common, both disciplines will benefit. Actors will be able to use robots as training partners and in real productions, and human-robot interaction researchers can harvest the insights into interpersonal interactions that are the bread and butter of actors.

Our immediate goals are to continue to refine the autonomous system, based on feedback from the actors, to give it a broader repertoire of behaviors, and to make these behaviors more robust. Adding additional sensor processing will allow the robot to more reliably detect the human actors, and to react to them appropriately. We also plan a graphical interface to our system, to allow performing arts professionals to more easily use our system in their movement classes, without having to resort to programming the robot themselves.

While our initial results are encouraging, their long-term utility is still an open question. Changes in actor behavior were observed in the autonomous demonstration, but whether or not these were long-lasting is unknown. The only way to answer this question is with a more in-depth study. To do this, we are planning on working with two groups of students over the coming months. We will instrument the performance space, enabling us to accurately track people with it using video cameras. A group of students will perform Viewpoints exercises weekly for a semester in this space, working with the robot. Their performance will be evaluated before the semester, at the end, and again two months later, to see if there is any change in their Viewpoints performance, and if it seems to be long-lasting. This will be compared to a control group, who will train with the same frequency, but without a robot. If there is a demonstrable difference, then this is evidence that our approach to using robots as teaching aids in the performing arts yields concrete benefits.

One larger concern revolves around the idea of robots as teachers. Usually, when robots are involved in teaching or learning, they are on the receiving side of the instruction, e.g. learning behaviors by repeated examples. The few examples where robots are teaching involve younger students or those with developmental disabilities; they are not generally used to teach a complex craft like acting technique. It is significant that the students were older and still were able to learn from the robot, because one would expect their maturity would make them less likely to accept that the robot would have something to each them instead of just a piece of simple technology.

We can only speculate as to why a robot helps to learn advanced topics such as this. We believe that the benefit comes from the students' perception of the robot just as much as what it actually does. One key point is that the robot was introduced as an expert in the field. When the robot was then seen to be performing the exercise as the students imagine an expert might, they can easily assume that the robot is in fact an expert. This allows them to develop a theory of mind for the robot, fitting into the role of "a thing that follows the rules of Viewpoints." The students can then respond by changing their behavior to match what they perceive the expert is doing. This type of teaching by example is beneficial because the human students can combine their ideas of what they should be doing with certain qualities and behaviors from the robot. By keying in on the natural human perception of robots, and by playing to the strengths and capabilities of today's robots, using robots as a teaching tool will likely provide a new interesting pedagogical experience in the future.

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