Moving in Tandem: Automated Person Pacing for Wheelchair Users

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Abstract

People like to move along with other people as they are going from place to place. For a person who is in a power wheelchair, this can be a difficult task. One must track the person they are accompanying, navigate towards the destination, maneuver around obstacles, and avoid colliding with or inconveniencing the person they are accompanying. This paper discusses a low-cost/low computation method of augmenting a semi-automated wheelchair with the capability to pace another person. This method uses a commercial color tracking system as its basis.

1 Introduction

One of the activites that most people carry out completely unconciously is to be able to identify and track people in their immediate environment. In particular, when a person has been introduced or has been identified to another person, then that person can easily be followed (by gaze) or picked out of a scene. This capability is usually done using face recognition, shape identification and by using other visual cues.

However, under certain conditions, people can, and do, identify other persons strictly on the basis of color blobs. This is the primary method of identification used by people who are nearsighted and are not wearing their corrective eye lenses. Under theses conditions, a person is identified by their hair, skin, and clothing colors. Identification by this method can be quite reliable, though it often needs up-close calibration when a potential identifyee changes their outfit. Nonetheless, thousands of teenagers, who refuse to wear their unstylish, glasses, get through high school in this manner.

This method of person identification and tracking (by a linked arrangement of color blobs) can be used by robotic systems at reduced cost and complexity when compared to other more tradional sytems of visual person tracking. The rest of this paper details a proposed method for implementing such a system and how it can be used in an automated wheelchair to relieve the operator of much of the strain of controlling the chair when accompanying another person on a journey.

2 Pacing

When two or more people are maneuvering their way through the environment together, they engage in an intricate behaviour that we will refer to as *pacing*. This refers to their capability to walk next to one another, adjusting speed and position to maintain their relative positions to one another.

For power wheelchair operators, this can be a very arduous task. A wheelchair operator is not as maneuverable as the person that they are pacing. The wheelchair operator must avoid a different class of obstacles and navigation hazards then confront a walking person. Additionally, a wheelchair operator is usually in a wheelchair, particularly a power wheelchair, for a reason – and the condition that placed the person in the chair often has affects that reach beyond the person's mobility. These conditions can sometimes also affect the individual's perception, coordination, fine motor skills or other capabilities that could be useful in the pacing activity.

When a power wheelchair bound person is pacing another individual, they must move their chair in a coordinated fashion to avoid obstacles and maintain the same general orientation with respect to the other person. This usually involves shifting the operator's gaze from straight ahead to the side, and back again.

Occasionally, the situation will demand that the relative orientation between the people does change, as when they are going through a doorway, or moving through a crowd. Under these conditions, the original orientation needs to be recovered, or a new orientation needs to be established that carries on the purposes of the original (e.g., switching sides still allows a conversation to continue). In any event, the key individual must remain identifiable to the chair operator and knowledge of their relative position must be maintained.

3 Tracking from a Wheelchair

During a pacing activity, certain features of the person being tracked remain relatively invariant, while others can change radically. The person's rotational orientation around the vertical axis (Z) can change radically while the orientation about the horizontal is invariant. The person will not always be in line of sight and may also be partially occluded from the wheelchair operator.

Given these factors, tracking should not be based on fine features such as the logo on a t-shirt or the features of the individual's face. As orientation changes, those features will change appearance or dissapear. By blurring the image and looking at the person as a stack of color blobs, a relatively invariant model of the person may be obtained. Most people can be modeled as (from the top down): hair color, skin color, shirt color, pants color, shoe color. Occasionally there are more (e.g., bare legs or exposed socks) and sometimes less (e.g., wearing a jump-suit or a dress). This vertical stack of colors is quite identifiable. Sometimes a color might dissapear (e.g., when looking at someone's back, no skin color may be identifiable, and the hair color blob might be larger) and more rarely a color might change (such as a t-shirt with a radically different front and back color), but those situations are somewhat unusual. Even in those unusual situations, the order of the colors will not change (unless the person being tracked suddenly starts walking on their hands – which would be *most* unusual).

The technology now exists to track color blobs in a video image at frame rates [**?**]. We have used this technology to do target tracking for a variety of robot tasks (e.g., spacecraft docking [**?**]). We propose to use these same techniques to track the color stack of a person being paced by a semi-autonomous wheelchair such as that described in [**?**, **?**, **?**].

4 Background: The TinMan Chair

The TinMan wheelchair places a set of contact, range and proximity sensors, along with a supplementary controller inline between the user's input device (e.g., joystick) and the chair's motor controller. The resulting system uses a reactive behavior control ([**?**]) program to take directional commands from the user, and modify the commands as needed to avoid local obstacles.

The system is designed to be used by wheelchair-bound individuals who would otherwise need assistance in maneuvering through their environment. The TinMan system can be used by people suffering from: low-acuity or tunnel vision; from severe spasticity; or people who require a seating position in their wheelchair that limits their forward vision.

5 Proposed System

We propose to augment a TinMan wheelchair with a color camera system mounted on a pan platform, and a head tracking system. The latter is simply a sensor which detects where the user's head is facing, and passes the information to the camera pan platform.

When the user wants to pace someone, they look at that person and then press a dedicated button on the user interface of the wheelchair. This causes the camera to turn towards that person, and also trains the system on that person's *color stack*. The pacing software then keeps the person centered in the camera, and tries to maintain a constant image size for the person being paced (this corresponds to maintaining a consistent distance to the person).

The camera will try and keep the person being paced centered in the image. This will require the pan head to be servoed by the image. Since the pacing activity desires to maintain the relative orientation of the pacer and pacee, the changes in camera pan position will be fed back into the chair navigation system to alter the chair's movements.

The motion of the chair cannot be completely directed by the motion of the person being paced, but must also take into account the terrain being traveled. Additionally, pacing is not a completely passive activity; it is a joint activity. The chair can not allow its goal of maintaining a constant orientation with the person being paced dominated over navigation safety concerns or the operator's own navigation goals. Thus, when the operator wants to move through a doorway, the chair should not just yield to the person being paced and start rotating next to the door jamb in order to maintain the proper relative orientation. The chair needs to maneuver through the door; or if that would lead to a collision, the chair should pause, letting the pacee go through the door – suspending its orientation goals temporarily. Once the chair is through the door, it can try and reestablish the orientation goals it originally had. Ideally it should, after a change of position such as the situation just described, be able to establish a new, but of similar value, orientaition goal (i.e., switching sides) if that is more expedient.

6 Conclusions

The existance of an intelligent physical agent requires more than just maneuvering through the environment without bumping into things. It must be able to do more than pursue goals. An intelligent agent must also be able to interact in the physical world with other physical agents, and follow the protocols for doing so that civilization has established.

Moving through a crowded environment in tandem with another person is a good example of this type of task. Using a human teamed with an intelligent artificial agent (as in a wheelchair/operator pair) and how that team interacts with the rest of the world, is a good test of the validity of the team. The work proposed above will test the ability of an artificial agent, getting its goals from a person and interpreting the implied goals of another, to function in the real world. Such a system will be of benefit to the intelligent robotics community and to those people with mobility disabilities as well. We are presently pursuing research towards the creation of the system described above. We hope to have some preliminary results in the not too distant future.

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