Autonomous vehicles moving as a human group

Francesco Zanlungo[1], Zeynep Yücel[1,2], Florent Ferreri[1], Jani Even[1],
Luis Yoichi Morales Saiki[1,3] and Takayuki Kanda[1‡]

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Social robots assisting or accompanying humans, as well as autonomous small size vehicles transporting them (e.g. automatic wheelchairs) may need to replicate human pedestrian group behaviour, so that the people moving along them, or being transported by them, may feel the interaction as comfortable and natural [1].
A recent work on pedestrian behaviour [2] considered the need of pedestrians to keep their distance r close to a maximum comfort one, r_0, while trying to minimise the angle θ that their gaze has to span between their walking goal $\mathbf{g}$ and their partners' gaze, and introduced the potential for interaction between pedestrians as

$$U^\eta(r,\theta) = C_r\left(\frac{r}{r_0}+\frac{r_0}{r}\right) + C_\theta\left((1+\eta)\theta^2 + (1-\eta)(\theta-\mathrm{sign}(\theta)\pi)^2\right), \tag{1}$$

(where $1 \leq \eta \leq 0$ is a parameter that makes groups walk slower than individuals outside groups, and causes 3 people groups to assume their typical V shaped formation), defined the "group interaction force" $\mathbf{f}_{group}$ as its gradient

$$\mathbf{f}_{group} = -\nabla U^\eta(\mathbf{r}), \tag{2}$$

and defined the pedestrian acceleration as

$$\mathbf{a} = \mathbf{f}_{group} + \text{collision avoidance and path planning terms} \tag{3}$$

In this work we implemented this social behaviour in a group of three robots. We did it through a two step process:

1. First we implemented it in a realistic simulator (i.e. using a map of the real environment in which we intended to deploy the actual robots and taking in account robot locomotion limitations) in which also a few (virtual) pedestrians where moving
2. After careful calibration of the parameters (e.g. collision avoidance terms) in the virtual settings, we proceeded to implement the system in three icart-mini robots from the T-frog project `http://t-frog.com/`.

Simulated robots resulted fully able to replicate human group behaviour in free space and in presence of (moving) obstacles, while our preliminary robot implementation reproduced group behaviour navigation in a complex environment (in absence of moving obstacles), Figure 1.

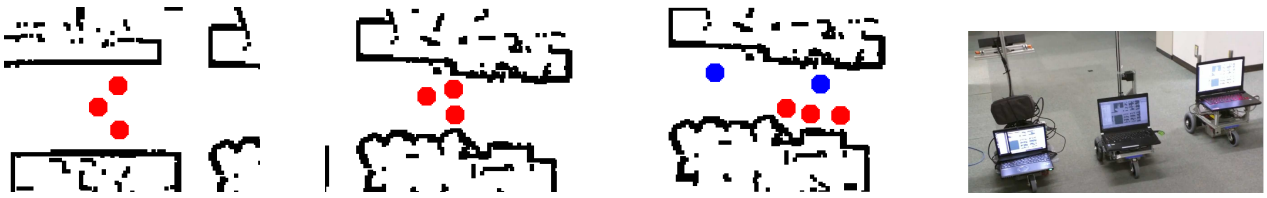

Figure 1: From left to right: 3 virtual robots (red) moving freely in a wide V formation; through a narrow passage; in presence of 2 virtual pedestrians (blue); actual robot implementation.

References

[1] R. Murakami, L. Y. Morales Saiki, S. Satake, T. Kanda, and H. Ishiguro. Destination unknown: walking side-by-side without knowing the goal. In *Proceedings of the 2014 ACM/IEEE international conference on Human-robot interaction*, pages 471–478. ACM, 2014.

[2] F. Zanlungo, T. Ikeda, and T. Kanda. Potential for the dynamics of pedestrians in a socially interacting group. *Physical Review E*, 89(1):012811, 2014.

*[1]ATR labs, Kyoto, Japan
†[2]Okayama University, Okayama, Japan
‡[3]Nagoya University, Nagoya, Japan