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Autonomous flying blimp interaction with human in an indoor space

Key words: Robotic blimp; Human-robot interaction; Deep learning; Face detection; Gesture recognition

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Motivation

1. Autonomous robotic blimps are the preferred platform for human-robot interaction (HRI) in applications where human comfort is a major concern.

2. There is a lack of dedicated designs for autonomous blimps to support experiments in human interaction with flying robots in an indoor lab space.

3. It is difficult for unmanned aerial vehicles (UAVs) with strong propellers or the existing blimps to enter a human user's intimate space and collect human data without prompting anxiety on the user.

Main idea

1. The Georgia Tech Miniature Autonomous Blimp (GT-MAB) is designed to collect experimental data for indoor human-robot interaction.
2. Perception algorithms are developed to detect a human user and identify human intentions.
3. Vision-based feedback controllers are designed to enable GT-MAB to follow the human user.
4. Immediate visual feedbacks on GT-MAB can significantly improve the interactive experience.
5. HRI experiments are conducted with multiple human participants, and a user study is presented.

Method

1. An onboard wireless camera is installed on GT-MAB to capture real-time videos of a human user.

2. A deep learning algorithm is implemented for GT-MAB to detect human face and recognize human's gesture.

3. Three feedback controllers are designed to control GT-MAB based on the estimated position of the human relative to the blimp.

Major results

Hardware design:

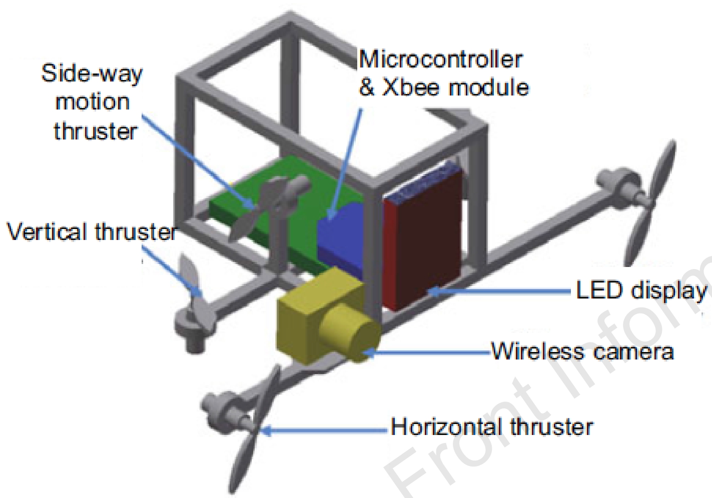

Fig. 2 Georgia Tech Miniature Autonomous Blimp gondola with the installed electronic components

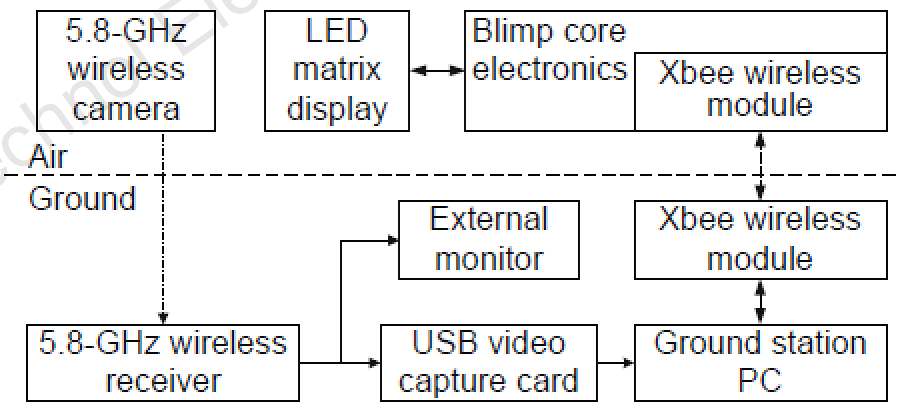

Fig. 3 Hardware overview

Major results (Cont'd)

1. Human following experiment

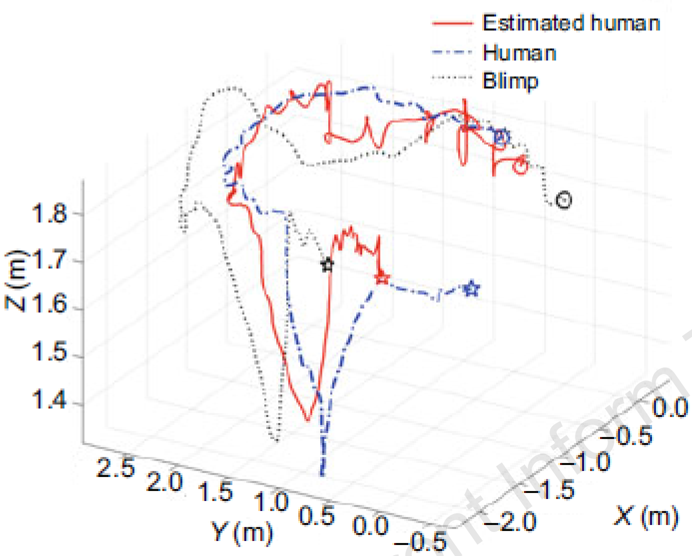

Fig. 9 Three-dimensional view of the estimated human, true human, and blimp trajectories. The starting positions are represented by the circles, and the ending positions are represented by the stars. References to color refer to the online version of this figure

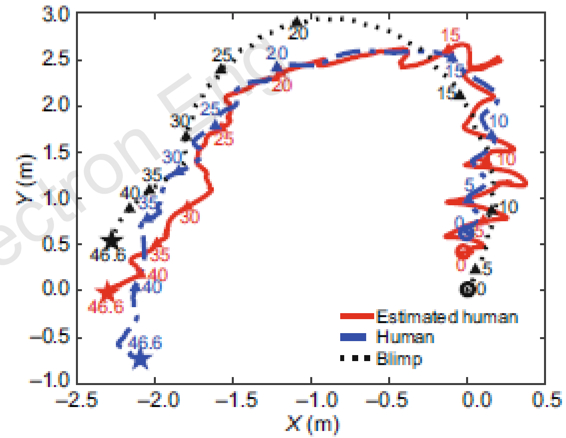

Fig. 10 Top view of the estimated human (red solid), true human (blue dashed), and blimp (black dotted) trajectories. The numbers in the figure represent the time in the unit of seconds, showing when the trajectories visited the points represented by the triangles. References to color refer to the online version of this figure

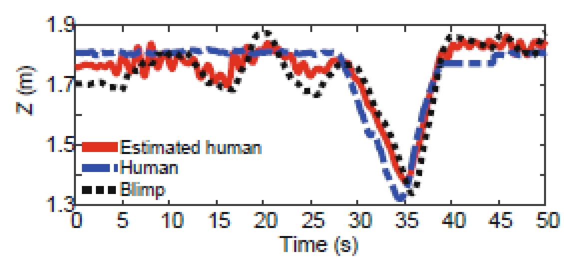

Fig. 11 Z positions of the estimated human, true human, and blimp trajectories

Major results (Cont'd)

2. Human gesture recognition results

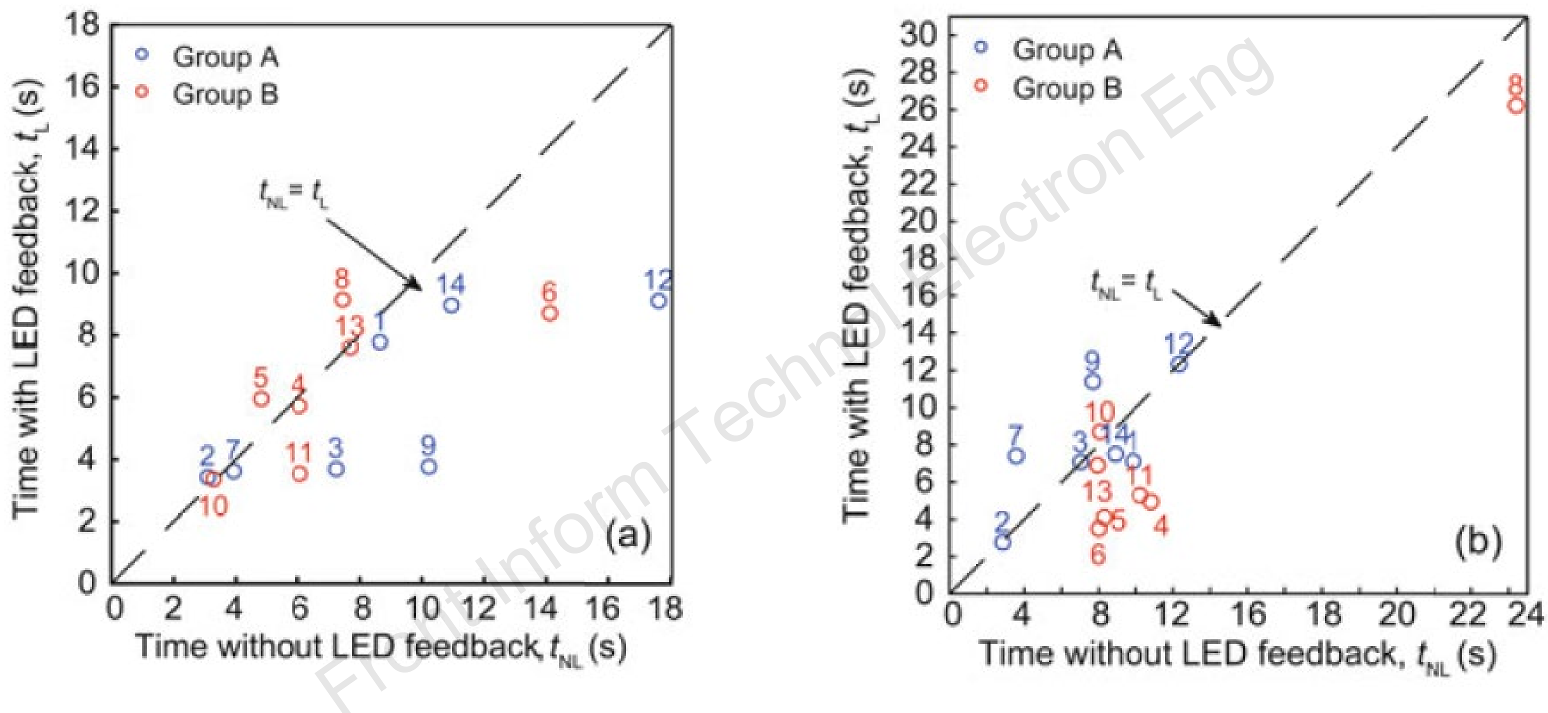

Fig. 12 Time duration for gesture recognition: (a) horizontal gesture; (b) vertical gesture. The red circles represent the data from group A and blue circles represent the data from group B. The dashed line represents the line where $t_{NL} = t_L$. The number near each circle represents the index of each user. References to color refer to the online version of this figure

Major results (Cont'd)

3. User study

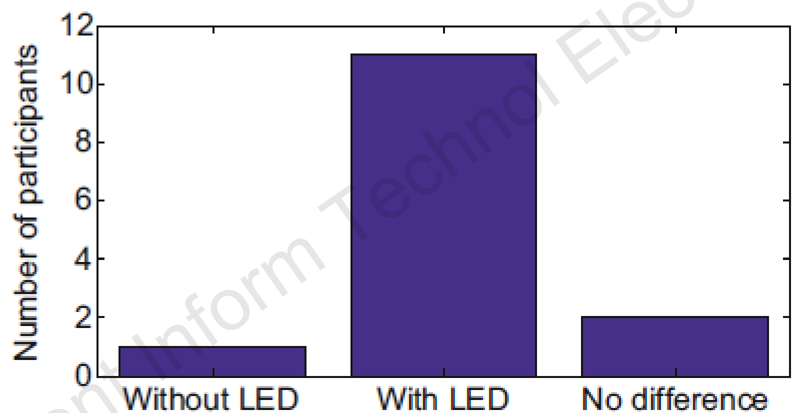

Fig. 13 Users' preference of a better human-robot interaction experience

Conclusions

1. We have presented a novel robotic blimp platform equipped with only one monocular camera, which enables an uninstrumented human to use hand gestures to interact with the robot.

2. A novel HRI procedure is presented to achieve a natural and smooth interaction.

3. A user study was conducted to verify that the proposed HRI procedure can enable natural interaction between a human and a robotic blimp.