Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 105 (2017) 7 – 13

Procedia Computer Science

2016 IEEE International Symposium on Robotics and Intelligent Sensors, IRIS 2016, 17-20 December 2016, Tokyo, Japan

Design and Analysis of a Multiple Tentacle System for Mobile Manipulation in Micro Aerial Vehicles

Joe Woong Yeol[a], Donald Toohey[a], Yong-Won Hwang[b]

Mechanical Engineering Department, Tennessee State University, Nashville TN 37209 USA
Center for Robotics Research, KIST (Korea Institute of Technology), Seoul Korea

Abstract

In this paper authors present a novel mechanical design for tentacle system for mobile manipulation in small MAVs (micro aerial vehicles) and its kinematic analysis of a single DOF (degree of freedom) tentacle system to be used for various possible operations. The main objective of this paper is to introduce a simple but effective tentacle design for MAVs and its kinematic analysis. The tentacle system is cable-driven, using two servos, 3D printed, and 9.5 cm long and weighs 0.1 kg [1]. Recent advancements in mobile manipulation facilitate aerial robots to perform various tasks that flying-only vehicles can't do. Conventional mobile manipulation systems are designed to have dexterous light-weighted manipulators installed in the body of aerial vehicles to enable interactions with the environment including welding, object pickup and release, and even cooperative task assignment. One of greatest challenges in mobile manipulation is additionally attached of manipulators in the limited payload of aerial vehicles. However, most of the dexterous mobile manipulators still add enormous payloads to the aerial vehicles. In this paper, a tentacle based mobile manipulator has been developed, analyzed in its kinematics, tested for operations, and discussed for future applications.

Peer-review under responsibility of organizing committee of the 2016 IEEE International Symposium on Robotics and Intelligent Sensors(IRIS 2016).

Keywords: multiple tentacles; micro air vehicles; drones; aerial robot; mobile manipulation

* Corresponding author. Tel.: +1-615-963-5390; fax: +1-615-963-5496
E-mail address: wjoe@tnstate.edu

Peer-review under responsibility of organizing committee of the 2016 IEEE International Symposium on Robotics and Intelligent Sensors(IRIS 2016).
doi:10.1016/j.procs.2017.01.180

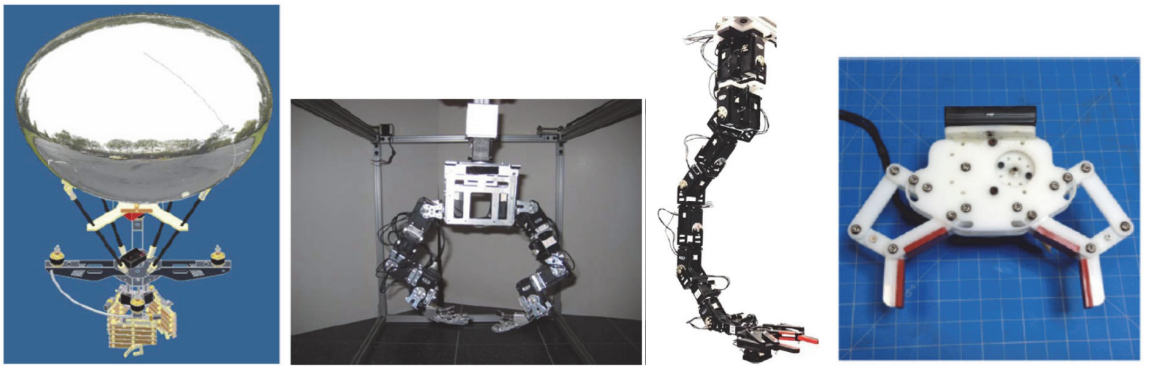
1. Introduction

The extended locomotion for robotic systems is a key playing role in the future development of aerial robotics. We humans use legs for different purposes for walking, running, jumping, and even swimming. We all including animals use our tentacles or arms and legs to actively interact with the environment to achieve certain tasks and goals. Almost all animals on earth use some types of arms, legs, or tentacles for their motions and aerial robots also need them for the same reason and purpose. There is no doubt that unmanned aerial vehicles present great advantages. However; these robots operate differently from the ways animals use their limbs for multi-locomotion movements.

This paper is composed of four main sections. The first section: Related work, provides the problem statement and a review of related research. The second section: Prototype design, introduces CAD and 3D printed models of the tentacle system. The third section: Analysis, provides fundamental kinematic and dynamics equations of motions of the suggested system and simulation results. Then the paper is summarized in Conclusion with additional future plans. Most of the mobile manipulation research works are focused on stability and control of aerial platform while a single or multiple manipulators perform various in-flight tasks since the attached manipulators are highly redundant, dexterous but heavy (minimum 5kg) which continuously change dynamics of manipulators and flying platforms. The main objective of this research is to design, demonstrate, and analyse a light tentacle system (about 0.1 kg) which does not interfere with any dynamical properties of aerial vehicles in its operation.

2. Related work

Work that is similar to that which the author pursues in this paper has been led by P. Oh's group at Drexel University. This group has been publishing papers related to this topic since 2012. The first paper was presented in ICRA 2012, entitled "Flight stability in aerial redundant manipulators" [2] and it presented a developed aerial manipulation prototype for testing the concept and its effectiveness. The system is called "hybrid quadrotor-blimp prototype" and was built by a group of students. However, this research as well as a consecutive publication [3] expressed major concerns about their payloads. By the nature of aerial platforms, payloads from additional tentacles, manipulator, or grippers are critical during flight, which causes stability issues. Their approach is to develop aerial platforms with a dexterous manipulator which typically weighs more than 20 kg.



(a) (b) (c) (d)

Fig. 1. (a) Hybrid quadrotor-blimp prototype [2-3], (b) mini-gantry test rig with dual manipulator attached [2-3], (c) hyper redundant manipulator [4] and (d) its end-effector's compliant design (Open) [4]

The group has continued research on the single or dual off-the shelf dexterous manipulator-equipped aerial platform and control by performing dynamics behavioral experiments in mini-gentry test rig shown in fig. 1(b) [3]. Most recent results have been published [4] and the group now focuses on the development of a hyper redundant manipulator shown in fig. 2. To effectively perform complicated tasks using an aerial vehicle with a dexterous manipulator, it is necessary to have highly redundant or multiple degrees of freedom manipulators. So, the current research that this group is working on is still static. The group is investigating analysis of dynamic behaviors of