TrayDrone – A Flying Helping Companion for in-situ Payload Delivery in the Smart Home

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ABSTRACT

The vision of using drones for instant delivery is not very far out anymore. Press releases from companies like Amazon are already suggesting that this technology will re-define the last hop of delivery to end users. This paper explores this concept in a much smaller scale: The use of a flying tray for micro payload deliveries in the context of the smart home, in particular the kitchen. We built a custom made drone that carries a roundly shaped tray that can carry up to 1 kg payload. In this paper, we share our experience of deploying our TrayDrone prototype in a kitchen booth at an international kitchen fair. Our findings underline the convenience of TrayDrone but also identify issues that need improvement.

KEYWORDS

Human-Drone Interaction; delivery drone; smart home; voice-user interaction

Figure 1: TrayDrone is carrying a box to be delivered to the user in a smart kitchen environment.

[1]JerkyBot: http://www.shendrones.com/jerkybot/
(last accessed 02-20-2019)

INTRODUCTION AND BACKGROUND

As voice assistants enter more and more households the idea comes easily to mind to have new types of actuators nearby that receive commands and do something for you. Either for convenience reasons or to create special experiences in your current context. E.g. a user sits on the couch reading a book feeling too lazy to go to the storage room to get a can of juice. Why not saying "Alexa, bring me a can of juice!". And shortly after, the juice can is brought to you without any person having to do something. This may be a situation where the TrayDrone as a helping companion in a user's smart home sounds plausible.

Regarding the interaction with such a flying companion for a smart home, we decided to use a voice assistant (as most smart home devices do today). Interacting with a drone by voice, on the first glance seems like an impossible endeavor as the rotors create a very loud sound already. However, Fernández et al. [4] are using voice commands for interacting with a drone. While Wang et al. [11] equip a drone with microphones to filter rotor noises out, they can follow a person that is speaking with a drone – although the drone creates noise. Landau and van Delen [8] even enable positioning a drone using voice commands.

While Human-Drone Interaction [5] is becoming more prominent [3] for directly interacting with a user - most projects in the HCI community focused on either equipping a drone with a projector [2, 7] or a display [9, 10]. Using drones as a device for delivering micro payloads in a smart home context is yet underexplored. We build on research that suggests using drones as a companion for the smart home. E.g. Karjalainen et al. [6] suggest a friendly design for a smart companion drone. Most prominently, Agrawal et al. [1] suggested building drones into pieces of furniture to provide them on demand in a smart-home environment for delivering a desk or a lamp when it is needed.

While some concepts of always available delivery drones have been already introduced (e.g. JerkyBot[1]), we specifically developed TrayDrone to be a micro payload delivery drone that is used in a voice controlled smart home.

THE TRAYDRONE SYSTEM

In order to build the TrayDrone we collaborated with a Drone-Design company named Artfantasie. They created the mechanical design for us, manufactured the device, integrated the electronic parts as well as the flight controller. The drone comes with designed protectors for protecting the users and the environment from the drone's blades in case of a collision or crash. The flight controller is programmed in such a way, that even when bumping into a cupboard the TrayDrone will automatically bounce back and keeps flying. The tray itself has an air permeable honeycomb design in order to allow maximum air circulation (Figure 2) and measures a diameter of approx. 40 cm. The tray is positioned 10 cm above the rotors in order to allow adequate air flow even in cases when the tray may be completely covered with payload.

Figure 3: TrayDrone passing the drone-sluice.

Figure 4 TrayDrone landed on kitchen table.

Figure 2: The design of our TrayDrone uses a tray that is designed after an air permeable honeycomb design. Further it comes with designed protectors for protecting the users and the environment from the drone's blades.

EVALUATING TRAYDRONE INTEGRATION IN A SMART HOME

For evaluating TrayDrone, we integrated our prototype in a smart kitchen environment that is voice controlled. The purpose of this proof-of-concept study was to let people experience the TrayDrone flights live. Both interpretation and reaction to voice commands and drone control was done by a study assistant that acted as a Wizard-of-Oz.

We presented the following scenarios to passersby that were interested in interacting with TrayDrone:

At a kitchen fair, our industrial partner had a complete kitchen room with fully furbished kitchen furniture. Large glass doors on one side of the kitchen prevented other visitors to enter the kitchen during the flight of the TrayDrone. On one side of the kitchen-wall, we built an automatic sluice door with a size of 120 cm in height and 120 cm width (see open drone-sluice in Figure 3).

Procedure: After our protagonist - who was standing inside the kitchen - said the words: *"Alexa, bring me my food package"* the sluice door opened and the TrayDrone entered the Kitchen flying through the kitchen room toward the kitchen table and smoothly landed on it (see Figure 3 and Figure 4). While the rotors were moving slowly the protagonist took the food package off the TrayDrone. The package included a box of noodles, salad an apple and some potato chips. Shortly after, the drone left the kitchen through the drone-sluice door into a dark room that was built next to the kitchen and landed on a table there. After that the drone-sluice door closed automatically (Figure 6). Due to the darkness of the room visitors could not look inside where the drone pilot was positioned and could not see where he always newly loaded the TrayDrone before it took off for the next flight.

The drone pilot was able to oversee the entire flight with his own eyes as he had to be able to maneuver the drone quite accurately and thus be able to react instantly if the drone would get out of control. During the day, we performed several TrayDrone-flights where approx. 50-60 spectators kept standing each time in front of the kitchen-showroom. We changed the payload flight by flight. Beside the food package, we delivered apples, vegetables, coke cans, pizza slices, and flowers (see Figure 5). A video of the TrayDrone in action can be found on Youtube (https://youtu.be/DbN02-532gk)

Figure 5   Various TrayDrone loads that we used during our proof-of-concept study where we integrated TrayDrone in a smart-home scenario.
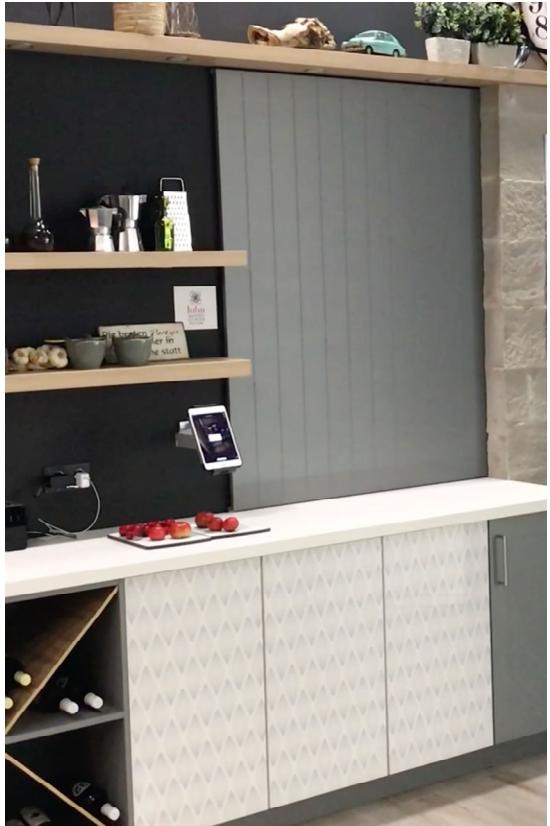
Figure 5 closed grey wooden drone-sluice

User statements:

Most visitors that saw the TrayDrone delivery live where stunned by the experience, telling that now the concept of delivery drones has become much more realistic and prominent in their own mind. However the big noise of the drone causes unease and may reduce the chances of deployability of such a drone system inside the house for everyday situations. However some elderly men stated that telling „*Alexa, bring me a beer*" sounds intriguing – but could become a reality.

Problems that we encountered during the experiment:

Strong air circulations. A drone of the size as we deployed creates a lot of wind due to strong air circulation caused by the drone's rotors. This mean in the kitchen all things standing around needed to be heavy enough to keep standing and all other things needed to be kind of fixed. In a real household as we know it until today, this is not the normal case and pose problems to a clean and order kept kitchen.

Obstacles. Obstacles in the kitchen can cause air cushion changes that affect the stability of the drone path. E.g. if the drone came near the kitchen table, the wind circulation under the drone changed thus the rotors had to bring different lifting power to the drone. This brings different kind of requirements to the drone's flight control system as compared to outdoor flights.

Staying in the same room. Not only a rather loud noise of the TrayDrone is a problem, but also the chance to collide with a TrayDrone is seen as a risk.

RESULTS AND DISCUSSION

Autonomous flight. In order to make TrayDrone more usable it must be able to fly autonomous. Thus an indoor navigation system needs to be available in the house that delivers highly accurate position data in real time with high frequency. That system should be installable with limited efforts and should blend into the kitchen environment.

Loading the drone. In contrast to our showcase where we manually loaded the TrayDrone by hand, an automatized system would be sensible. This could be a robot with grasping arms that fetches things from a shelf or table and lays them on the TrayDrone once the tray comes close. Another idea could be many readily loaded trays that are stationed in a storage room in such a way that the drone can fly underneath and by lifting it picks up the tray and flies to the destination.

Battery size and weight. As flight time of one TrayDrone delivery cycle may typically be short in the smart-home context (in our fair scenario it was maximum 1 minute), the battery can be kept at minimum size in order to reduce the total weight of a TrayDrone system – thus allowing more payload compared to delivery drones used for longer distances outdoors.

CONCLUSION

In this paper, we presented TrayDrone, a drone for delivering micro payload in a smart home environment. Through a proof-of-concept study at a booth of a trading fair, we elicited first reactions of passersby when seeing our system in action. Further, we identified benefits and challenges regarding using a drone in an indoor environment in a smart-home context.

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