* Project title (make this the title of the post too)

Hybrid Plant in Augmented Reality Space

* Key project image
* Project description (250 words max)

This project attempt to present a Tangible Interface on physical plant with virtual on-screen contents in Augmented Reality space. Most AR experiment on mobile or on Mixed Reality glasses focus on screen-based interaction with gestures. However, I think these experiments have less engagement with the physical context. Moreover, most AR experiment have less connection between the physical and virtual elements, they just separate in the space. This project attempt to provide more engagement experiment with the physical plant and the virtual content for the topic Tangible Interface and anchor the virtual content onto the plant to expand the concept of Hybrid object. There are three sensors are installed in the plant, two of them are Ultrasonic Sensors and other is Photoresistor. The Ultrasonic Sensors are installed the two side of the plant, and the photoresistor is on the top of the plant. The interaction happens on how people touch different point around the plant with their two hands. The virtual plant is visualized as particle in the AR space, and the touching of different point and combination touching with hand will affect the movement of the particles. Behind the sense, I used MQTT as the framework for agent to agent communication. The sensors in the plant capture data from the context and this information is host and send by the ESP 32 to cloud and then to the visualized devices. Unlike the traditional service to client communication, this method enables agent-to-agent to communicate directly by publishing and subscribe to topic.

* Experience Video (1 minute max)
  + This should focus on the overall experience of the work from the perspective of the intended audience. (inside or out)
* How It Works Video (2 minutes max)
  + This video focusses on the "behind the scenes" look at the technical and design strategies used
* 2-5 final project images
  + focused on how the project interacts with "users" and the site
* 2-5 development images/videos
  + Documenting the technical development
* Link to the Arduino and Processing code hosted on GitHub
* Circuit diagram, created in Fritzing or Tinkercad
* Project Context (300-500 words)  
  Write about 2-4 references to related articles, papers, projects, or other work that provide context for your project. Discuss the relationship between your project and these references. Be sure to include a bibliography and use a consistent citation style.

Billinghurst mentions that the AR display and tracking techniques for interaction with AR space is limited, by passive viewing or browsing virtual information simple. Although some systems provide manipulation, adding and deleting virtual object in AR scene, they are still having less engagement with uses (Billinghurst). To expand the interaction in AR, they present a new approach Tangible Augmented Reality for designing AR interfaces. The concept of Tangible AR interfaces require a virtual object anchor to a physical one, they are equally important for interactions (Billinghurst). My project is an example of how I think of the tangible AR interface in the framework of Billinghurst. By touching different special points on the plant, the virtual particles are able to perform various movement in AR space, and it is how I bring the physical interaction into the AR interface.

Lok addressed that most virtual environment (VEs) are only include virtual objects, and they presented hybrid environment (HE) system for getting physical objects into VRs (Lok). The interaction with digital objects in physically manipulating is still an issue in immersive virtual environment (Krause), and this also happen in the augmented reality space. Krause says that the used of hybrid object in virtual environment can enhance the aligned of physical and virtual parts toward seamlessly. This project expanded the concept of hybrid environment (HE) to hybrid object (HO), which means that object have virtual and physical body in a mixed reality space. The virtual particles, which visualized by the device, around the plant can be responded to the physical touch of the plant. Such physical action present on the virtual part of the object can be defined as the unity of virtual and physical.

The connection of the virtual and physical is one of the big challenges of this project, the Internet-of-Things framework help me embody my project of the wireless connection. This IoT-enable plant perform a simple context-awareness and send the data to the visualized device. Unlike the traditional framework of using server to client communication, this project test the MQTT framework in which to enable the agent-to-agent communication (The Standard for IoT Messaging).

Billinghurst, Mark, Hirokazu Kato, and Ivan Poupyrev. "Tangible augmented reality." *ACM SIGGRAPH ASIA* 7.2 (2008): 1-10.

Lok, Benjamin, et al. "Experiences in Extemporaneous Incorporation of Real Objects in Immersive Virtual Environments." *Proc. IEEE Virtual Reality 2004*. 2004.

Krause, Frank-lothar, et al. "Usability of hybrid, physical and virtual objects for basic manipulation tasks in virtual environments." *2007 IEEE Symposium on 3D User Interfaces*. IEEE, 2007.

“The Standard for IoT Messaging.” *MQTT*, mqtt.org/.