BRIDGING THE PHYSICAL, THE DIGITAL, AND THE SOCIAL

The scope of the column includes IoT technological achievements that have social impacts and/or incorporate social factors. Each column will provide knowledge and insights in the most recent developments, cutting-edge applications, latest deployments, and conceptual innovations, and of course, their implications on our society. I hope the columns will be meaningful in understanding how our society interacts, adopts, adapts to, and changes with IoT technological advancements.

Introduction

COLUMN EDITOR
Jun Zhang

How to integrate various technologies and enable a city-wide IoT? How to turn around real-time data fast enough in time for immediate system control measures? The SAP may provide its unique answers and practices around the globe.

ParadeTalk: Innovative Interactions between Parade and Audiences Using IoT

by Yi-Bing Lin, Yun-Wei Lin, and Kin Hui

Abstract

This column describes ParadeTalk, an IoT based system that allows innovative interactions between parade floats and audiences. By using the sensors and the actuators of AgriTalk, a commercially operated smart agriculture solution, we implement ParadeTalk in the Singpoli parade float of the Pasadena Tournament of Roses Parade in California, USA. We describe how the sensors/controls are connected to the objects in the parade float. We hope that parade audiences will learn basic ideas of smart farming in the rose decorated float when they enjoy interacting with the float. We also analyze how the delays of the IoT messages affect the interaction between the parade flow and the audience members. ParadeTalk is a success story that implements a sustainable IoT application commercially operated.

Introduction

This column describes two success stories and shows how they can be integrated through Internet of Things (IoT) to make a bigger dream. The first story is about the Rose Parade produced by the Pasadena Tournament of Roses in California, USA [1]. The first Tournament of Roses Parade was sponsored by the Valley Hunt Club. At a club meeting in 1890, Professor Charles F. Holder announced, "In New York, people are buried in snow. Here (Pasadena) our flowers are blooming and our oranges are about to bear. Let's hold a festival to tell the world about our paradise." Therefore, in the midst of winter, the entrants decorate carriages with plenty of colorful flowers in a parade that includes bloomy floats, spirited marching bands and high-stepping horse-riding units. After a century of evolution, the parade floats are a wonder of advanced technology behind the flowers and other natural materials. There are parade float competitions for float design, floral presentation and entertainment value. In 2018, Singpoli American BD's parade float "Rising Above" [2] won the Sweepstakes Award for the most beautiful entry, which encompasses float design, floral presentation and entertainment. In this Singpoli parade float, the rose decorated fish can make different gestures through motors controlling the fish's fins, eyes, mouth, etc. In the past, several parade floats were designed with motor-driven decorations [3], but none of them can interact with the parade audiences in real time.

In 2020, Singpoli American BD decided to establish a smart farm using the AgriTalk technology [4]. AgriTalk is another success story, which utilized IoTtalk [5], an IoT device management platform to achieve organic smart soil cultivation. At the 2019 World Congress on Information Technology (WCIT), the largest IT Congress for innovators and entrepreneurs, the AgriTalk IoT system won the Digital Opportunity/Inclusion Merit Award [6]. In 2020, the AgriTalk farming sensors won the CES Innovation award and were showcased at the Consumer Electronics Show (CES), Las Vegas, USA [7].

Based on the aforementioned two "success stories", this column presents ParadeTalk, an IoTtalk approach that integrates the Singpoli parade float and the AgriTalk farming mechanism to create interesting interactions between the parade float and the audiences. In particular, we use AgriTalk's control board to encourage the parade audiences to participate in collective interactions. AgriTalk's control board is web-based and can be browsed from a smartphone without installing any mobile app. This control board allows a large number of users to interact with other IoT devices, such as the objects in the parade floats. We hope that parade audiences will learn basic ideas of smart farming in the rose decorated float when they enjoy interacting with the float. We will address two technical challenges. First, how to transparently control the actuators of parade floats using AgriTalk sensors. Second, how to allow a large number of audience participants to interact with parade floats simultaneously.

The column is organized as follows. We introduce AgriTalk. We show how the Singpoli parade float can be integrated with AgriTalk. We evaluate the time complexity of the float and audience interactions. We conclude by summarizing our solution to be implemented in the Singpoli parade float at the 2021 Rose Parade.

AgriTalk: A Precision Farming IOT Solution

AgriTalk [4] is a precision farming solution based on an IoT device management platform called IoTtalk [5]. AgriTalk has been deployed in 10 island-wide smart farms in Taiwan (Fig. 1a) to grow turmeric (Fig. 1b), Danshen, white strawberry, cantaloupe melon, pineapple, etc. Five AgriTalk smart farms will be deployed around the world in Armenia (vine, strawberries), the Philippines (turmeric), California (turmeric), Kyushu Island, Japan (olives), and Kobe, Japan (turmeric). AgriTalk is able to remotely and automatically make precision farming decisions based on AI in order to manage the farm fields in real time. All partners who collaborate with AgriTalk are world-class multinational conglomerates, including Quanta Computer Corp., Chunghwa Telecom, Ucom (the largest private company in Armenia), Japan's NAGASE Corporation, Kyushu Olive Association of Japan, HIJO Resources Corporation of the Philippines and the Singpoli Group in the United States. In 2019, AgriTalk received potential orders worth USD 30 million at the world-famous CES in Las Vegas, USA. In the 2019 VC competition of the Silicon Valley Forum, AgriTalk won first place out of 44 teams. Figure 1c illustrates a popular AgriTalk machined turmeric powder product.

FIGURE 1. AgriTalk approach for organic turmeric cultivation: (a) One of the AgriTalk farms; (b) Turmeric; (c) The turmeric powder product.

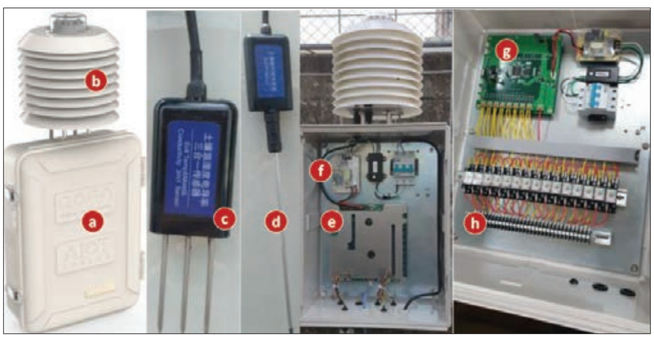

FIGURE 2. a) : QoFA1; (b) weather station: c) and d): soil sensors; e) QoFA1 MCU; f) POE; g) QoFA2 MCU; h) actuator control relays.

AgriTalk IoT devices are connected to two control boards that are the cores of the AgriTalk sensor product called QoFA1 and the actuator product called QoFA2. Both of them are manufactured by Quanta Computer Co. QoFA1 (Fig. 2a) consists of a weather station and soil sensors. The weather station (Fig. 2b) collects the environment data in the farm fields using the CO_2, temperature (–30°C~70°C), humidity (1~95% RH), atmospheric pressure and ultraviolet sensors. The collected data are used to map the climate conditions to drive the actuators for precision farming (sprayers, drippers, lights, and so on). QoFA1 also connects to soil sensors, including the 3-in-1 sensor for electrical conductivity (EC), moisture and temperature (Fig. 2c), and the pH sensors (Fig. 2d). The weight of QoFA 1 is 12kg, and its microcontroller unit (MCU; Fig. 2e) is the ARM926EJ-S 300MHz SoC running Linux 3.10 OS. The communication module is Ethernet 10BASE100 RJ45 with POE (Fig. 2f) that fully supports IEEE 802.3 Type 1. QoFA 1 provides RS-232 D-SUB 9 Pins, MicroUSB connector for ADB, RS-485 Port, and a USB Type A connector for engineering. The average power consumption is 7.4W and the maximal power consumption is 10W. The power connector is 100–240 VAC/50–60 Hz, the contact discharge is ±8kV, the air discharge is ±15kV, and the surge protection is 1.2×50μs, 15kV, 8×20μs, 7.5kA. The ESD protection is IEC/EN 61000-4-2 Level 4 and its water proof is IPX5.

The MCU for QoFA2 (Fig. 2g) is the same as that for QoFA1. The weight of QoFA2 is 16 kg, and the sensors in QoFA1 are replaced by the relays in QoFA2 with 16-channel terminal connectors (Fig. 2h). The maximal power consumption of QoFA2 is 17W. The operational humidity ranges from 20 percent to 95 percent, and the storage humidity ranges from 0 to 95 percent. The temperature ranges from –30°C to 70°C. The protection specifications for QoFA2 are the same as those for QoFA1.

Both QoFA1 and QoFA2 are designed for harsh outdoor environments, and provide accurate sensor data and precise control for at least three years. QoFA MCUs are connected to the AgriTalk server through wired or wireless communications technologies. The reader is referred to [4] for more details of precision farming.

FIGURE 3. ParadeTalk: a) the control board ; b) the video viewing board; c) and d) the dashboard.

FIGURE 4. Interaction between the audiences and the Singpoli parade float; (a)–>(b): the path from a camera to a viewing screen; (c) –> (d): the camera control path; (e) –> (f) –> (g): the fish gesture control path; (h) –> (i) –> (j): the sensor data display path; clicking (j) to shown the time series chart in (k)

Integrating Two Successful Stories

In the ParadeTalk approach, an audience member uses their smartphone to interact with the Singpoli parade float. We first describe how parade audiences interact with the floats using their smartphones without installing any mobile app. Then we show how ParadeTalk is implemented in the IoTtalk platform.

Audience Interface

Through the SmartphoneTalk technology [8], the audience simply uses a smartphone to scan a QR code, then a web-based window pops up (Fig. 3). The Singpoli parade float is configured with a smart light pole with three directional cameras and one omnidirectional camera (Fig. 4a), and the ParadeTalk server provides video streaming to the viewing window (Fig. 4b). The audiences can rotate or zoom in or out (Fig. 4c) through the camera motor (Fig. 4d). Note that a camera can only be manipulated by one audience member at a time. When the audience member presses the buttons of the control board (Fig. 4e), the control signals are sent to QoFA 2 (Fig. 4f) that controls the fish (Fig. 4g). For example, to interact with the fish eyes, an audience member presses the "Eyes" button (Fig. 3a), and the fish eyes (Fig. 3b) are triggered to open and close. To accommodate a large number of audience participants, a dashboard provides the status of how many people have clicked the buttons. Figure 3c indicates that there are 1000 clicks on "Eyes" and Fig. 3d shows that there are 200 clicks on "Tail". If there are more clicks on, for example, "Tail", the fish tail will wave

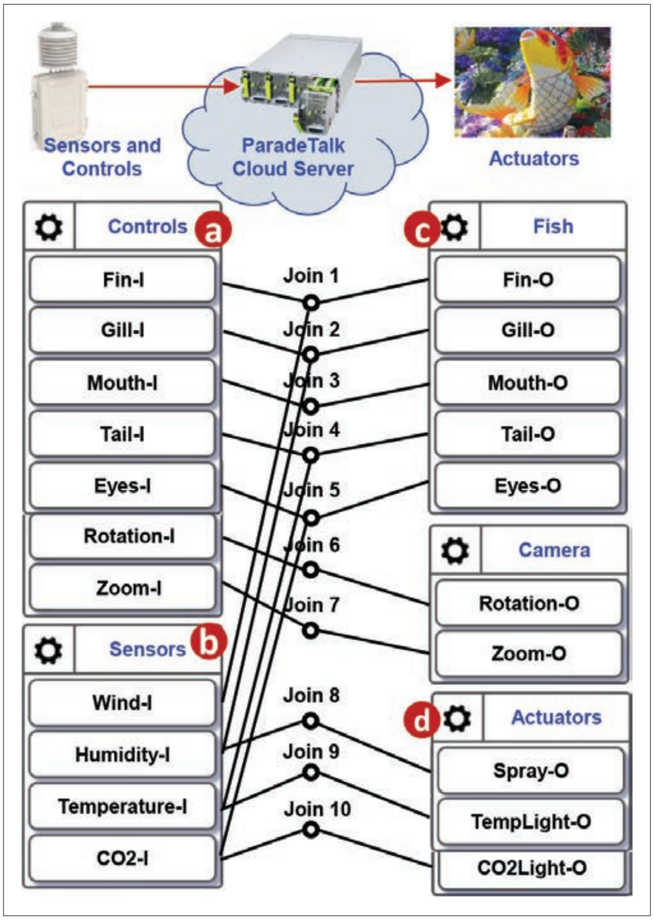

FIGURE 5. Configuration for ParadeTalk.

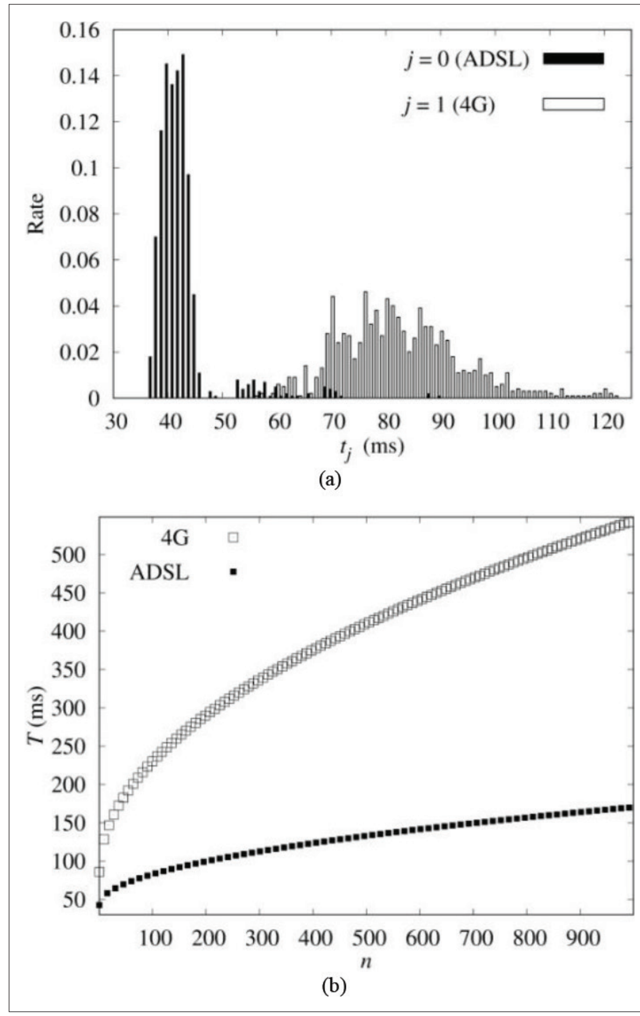

FIGURE 6. a) the histograms for t_0 (t_1); b) the relationship between T and n.

bigger. The click number is automatically decremented by the ParadeTalk server, and the tail stops waving when the count is decremented to 0. If the audiences want to see the tail wave again, they should click the "Tail" button again. Even if the Singpoli parade float is not in sight of an audience member, they still can enjoy watching and remotely interact with the float through the viewing window.

In the parade float, a small garden (Fig. 4h) is monitored by sensors connected to QoFA1 tracking the soil temperature, moisture, electrical conductivity (EC) and pH. The sensing data are collected by the QoFA1 control board (Fig 4i), and then sent to the dashboard of the smartphone (Fig. 4j).

Besides the sensors in the soils, QoFA1 also collects data on weather conditions through the weather station. In the smartphone, each sensor icon (Fig. 4j) in the dashboard can be clicked to see the time series of the sensed data (Fig. 4k), which provides the audience basic ideas about smart agriculture monitoring. For example, when the audience members click the spray button, they can see how the temperature and the relative humidity of the float change through the time series charts in the dashboard.

Implementing ParadeTalk Applications

Many applications can be easily built in the ParadeTalk control board. For example, we can implement "vote" buttons, and ParadeTalk would allow the parade audience to vote on the dream parade float in real-time. A similar example is the theater "Nomunent" [9] that enabled the audiences to collaboratively create a monument through a voting process.

Interactions between the sensors/controls and the actuators can be easily configured through the web-based ParadeTalk graphical user interface (GUI) illustrated in Fig. 5. In this GUI, the sensors are represented by icons grouped by a larger icon "Sensors" (Fig. 5b), and the control switches are grouped by the icon "Controls" (Fig. 5a). Note that we only list a few sensors and controls in Fig. 5. More sensors (such as the soil sensors) have been deployed in ParadeTalk to provide vivid interactions with the actuators. They are not shown in Fig. 5 to simplify our discussion. The fish actuators are collected in the "Fish" icon and other actuators are collected in the "Actuators" icon. To control an actuator by a sensor, we simply drag a line to connect the sensor icon to the actuator icon. A line has a "Join" circle in the middle. By clicking the Join circle, we can write Python control logic to manipulate the data sent from the sensor to the actuator. For example, in Join 10, we can write the following logic: if the received CO2 value is larger than 500, then the light CO2Light-O is turned on. In the Join link, the first segment connects the sensor/control to the ParadeTalk server. The IoT message transmission technology for the segment can be wired or wireless. The control logic implemented in the circle is executed by the ParadeTalk server. Based on the result of the execution, the server sends an instruction to the actuator through the second segment of the Join line. In Fig. 5, the fish fin is controlled by both the Fin-I control switch and the Wind-I sensor through the Join 1 link. As more audience members press the Fin-I control switch, the fin moves faster. Similarly, when the wind speed increases, it also affects the fin movement. In Join 8, when the relative humidity is lower than, say, 20 percent, the sprayer is triggered to spray water to cool down the float. To configure the relationship between the sensors/controls and the actuators, we simply connect them through the Join links. For example, to redefine the spray control so that when the fish tail waves the float also sprays water, we simply drag a line from the Join 4 circle to the Spray-O icon. The correctness of the configuration in Fig. 5 can be automatically and formally verified by a tool called BigraphTalk [10].

Time Complexity Analysis

The segment of a link between an icon and the Join circle represents the communication technology used for transmissions between the QoFA control boards and the ParadeTalk server. In AgriTalk, ADSL (Ethernet) is used for smart farming. Since the parade float is mobile in ParadeTalk, 4G LTE wireless technology is used to connect the IoT devices with the ParadeTalk server. It is clear that the transmission delay t_1 for 4G LTE is longer than the delay t_0 for ADSL. Therefore, we need to make sure that ParadeTalk works with longer delays (t_1) as compared with that (t_0) for AgriTalk. In [4] we have obtained histograms for t_0 (t_1) through 1000 measurements for each of the ADSL and the ParadeTalk server and the 4G transmission scenarios, which are illustrated in Fig. 6.

From the measured data illustrated in Fig. 6a, we computed the expected value $E[t_0]$ = 42.638 ms and the variance $V[t_0] = 0.018\, E[t_0]^2$ for ADSL transmission. For 4G LTE, $E[t_1]$ = 85.958 ms and $V[t_1] = 0.057E[t_1]^2$. It is clear that the delays for 4G are about twice that for ADSL. Also, the variance for 4G is higher than ADLS, which means that wireless communications are not as stable as wired communications. Fortunately, the transmission requirements of the parade float IoT devices need not be as strict as precision farming IoT devices. Delays of 85ms (less than 0.1 seconds) are sufficiently short for the ParadeTalk applications.

As we mentioned earlier, ParadeTalk can periodically decrement the counters for float objects such as "Tail". We need to design the period for decrementing the counters. The counter decrement is a mechanism that partially resets the audience votes to avoid an infinite increase of the counter value. On the other hand, this mechanism should be designed such that the counter value is not rapidly decremented to 0 or the target object will not interact with audiences with enough significance. Therefore, the period T and the decrement amount n are selected to avoid the counter value reducing to 0. The above goal can be achieved if at least n audience members click the button in the period T. (In other words, if n clicks have occurred up to time τ, then the first click should occur later than $\tau - T$. Suppose that n clicks occur at time τ, and among these n audience members, the i-th audience member clicked at time $\tau - T_{j,i}$, where j = 0 (for ADSL) or 1 (for 4G), and $1 \le i \le n$. In other words, $t_{j,i}$ is the delay between when the i-th audience member clicks the button and when the ParadeTalk server receives the click. Then it is appropriate to select

$$\max_{1 \le i \le n} t_{j,i}$$

for the counting mechanism. From the histograms in Fig. 6a, $t_{j,i}$ ($0 \le j \le 1$, $1 \le i \le n$) can be considered as i.i.d. random variables with the mean $E[t_j]$ and the variance $V[t_j]$. From [11], we have

$$T = E\left[\max_{1 \le i \le n} t_{j,i}\right] \le E\left[t_j\right] + \left(n-1\right)\sqrt{\frac{V\left[t_j\right]}{2n-1}}$$

Figure 6b illustrates the selected T against n. Based on this figure, we can select an appropriate T value for resetting the counts. The figure shows that by using 4G communication technology, ParadeTalk can support $n > 900$ with delay less than 0.6 seconds.

Conclusions

This column describes how to utilize IoT technology to integrate parade floats and smart farming, which provides real-time interactions between audiences and the parade float. Based on the IoTtalk platform, we developed ParadeTalk which integrates the Singpoli parade float and AgriTalk smart farming. Both of them are commercially and sustainably operated applications. The beauty of our approach is that ParadeTalk can reuse the existing parade float and AgriTalk mechanisms without extra costs aside from moving the farming IoT devices QoFA 1 and 2 onto the float and wiring the fish motor switches to QoFA 2. With the AgriTalk web based dashboard and control board, ParadeTalk allows many audience members to interact with the interesting objects on the parade float. Our experience [9] indicates that the audience is always excited about participating in activities through collective interactions. We hope to implement ParadeTalk in Singpoli's parade float in 2021. Our goal is to enable parade audiences to enjoy interacting with the float and allow them to learn basic ideas of smart farming in the rose decorated float during the interactions.

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Biographies

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Yun-Wei Lin (jyneda@nctu.edu.tw) received Ph.D. degrees in computer science and information engineering from National Chung Cheng University, Chiayi, Taiwan, in 2011. He has been an assistant professor in the College of Artificial Intelligence, National Chiao Tung University, Taiwan since 2019. His current research interests include mobile ad hoc networks, wireless sensor networks, vehicular ad hoc networks, and IoT/M2M communications.

Kin Hui (kinhui@singpoli.com) is the Owner and Manager of the Singpoli Group. The Singpoli Group of companies specializes in real estate investment and development, general construction, and property management, which included a stake in several successful real estate development ventures throughout the United States. He and Singpoli have supported a variety of regional nonprofits affiliated with prestigious local institutions, such as the Pasadena Symphony and Pops, Los Angeles Chinese American Museum and University of California, Irvine. On January 1, 2016, Singpoli's third Rose Parade float, "Marco Polo-East Meets West," won the prestigious Sweepstakes Award. During 2017, he led his team to work on the fifth float "Singpoli American BD 2018 Rose Float — Rising Above" and proudly won the top prize Sweepstakes Trophy again on January 1, 2018. He has been honored by the Los Angeles County Chinese American Sheriff Advisory Committee, the Boy Scouts of America, and the Association of Chinese-American Elected Officials. He has also been awarded Outstanding Leadership by the Chinese American Professional Society, Business Person of the Year 2015 by Arcadia Chamber of Commerce, and 2016 Congressional Leadership Award by Congresswoman Judy Chu. In 2017, the American National Association for the Advancement of Colored People (NAACP) Pasadena Branch presented him the "Corporate Award" to acknowledge his contribution to the local community. He currently serves as Honorary Chair of the Board of Trustees for the ASEAN People's Association of Los Angeles.

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Jun Jason Zhang (jun.zhang.ee@whu.edu.cn) received his B.E. and M.E. degrees in electrical engineering from Huazhong University of Science and Technology, Wuhan, China, in 2003 and 2005, respectively, and his Ph.D. in electrical engineering from Arizona State University, USA, in 2008. From 2011 he was an assistant professor and then associate professor in electrical and computer engineering at the University of Denver. Currently, he is a professor at the School of Electrical Engineering and Automation, Wuhan University. He jas authored/co-authored over 100 peer-reviewed publications. He is an associate editor of *IEEE Transactions on Computational Social Systems*, an associate editor of *Acta Automatica Sinica*, and an associate editor of *IEEE/CAA Journal of Automatica Sinica*. His research expertise is in the areas of complex system analysis, artificial intelligence, Blockchain, Internet of Things, knowledge automation, and their applications in intelligent power and energy systems.