JarPi: A Low-Cost Raspberry Pi based Personal Assistant for Small-scale Fishermen

Megh Hitesh Vora[1], Girish Bekaroo[1], Aditya Santokhee[1], Suraj Juddoo[1], Divesh Roopowa[1]
[1]Middlesex University (Mauritius Branch Campus)
Bonne Terre, Vacoas, Mauritius

***Abstract*— Small-scale fishermen face various occupational safety hazards due to unavailability of real-time weather information during fishing activities at sea. Whilst provision of such information could greatly reduce these risks, limited personal assistants exist that could support small scale fishermen in their activities at sea with real-time details on wind speed and direction, rainfall, humidity, geographical location and distance from shore, among others. Furthermore, large scale solutions are too expensive for this category of fishermen to afford. Even though the recent emergence of the Raspberry Pi showed to significantly decrease costs of computational systems, the application of this technology to build solutions for small-scale fishermen is yet to be investigated. As such, this paper investigates the implementation and deployment of a low-cost Raspberry Pi based personal assistant for small-scale fishermen, through a proposed device named JarPi.**

Keywords*— JarPi; Personal Assistant; Raspberry Pi; Small Scale Fishing; Low-Cost;

I. INTRODUCTION

While being resource constrained, small scale fishermen often face various challenges at sea or in lakes, especially due to weather conditions. For instance, because of being unable to correctly obtain or guess changes in weather conditions during fishing sessions, there have been various reported cases where fishermen have even lost their lives [1, 2, 3]. Furthermore, while being unsure of weather conditions and changes during a fishing session, it is challenging for fishermen to take decisions about whether to explore certain marine areas thus affecting catch and income of such type of fishermen [4]. Whilst it is rare to come across information systems that have been designed for small scale fishermen, people with this profession still have to use traditional methods to obtain weather related information from radio and local weather station on a daily or weekly basis. Moreover, such sources do not give real-time information in terms of wind speed and direction, temperature and humidity. As such, the absence of timely and accurate information poses occupational safety risks to this type of fishermen [5].

In order to minimize occupational safety risks, small scale fishermen could turn to personal assistants as solution to support in fishing activities while at sea. However, with their resource constraints, only low cost solutions would be relevant. During recent years, various personal assistants have emerged where key examples include Siri[1], S-Voice[2] and Cortana[3], among others. Although these mobile-based assistants simplify interaction at sea, such tools are not directly relevant to small scale fishermen. With the emergence of the Raspberry Pi (RPi), which is a low-cost, credit card sized single-board computer that was developed in 2012 by Raspberry Pi Foundation in UK [6], implementation of low-cost personal assistants could be realizable. Since its release in 2012, the RPi has become the fastest selling British computer where over 5 million devices were sold in just 3 years [7]. However, limited previous studies have demonstrated the use of RPi based personal assistants for weather forecast services and location tracking that can be used by fishermen during fishing activities.

One such personal assistant is AirPi, which is a Raspberry Pi shield kit that has the ability to record humidity, air pressure and temperature sensors along with sensors for light, UV levels, carbon monoxide and nitrogen dioxide [8]. Based on the information that is collected by these sensors, the current real-time weather conditions can be assessed by the fishermen as shown in Fig. I.

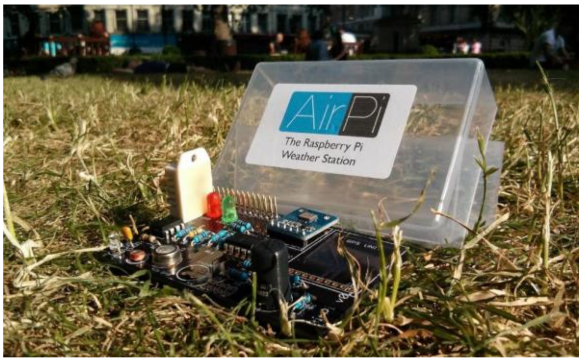

Fig. I - AirPi - A Raspberry Pi based weather station

AirPi is not customised for fishing activities and as such does not provide details on location at sea, time spent when fishing, amongst other parameters. Furthermore, using a mobile phone or laptop at sea itself is not feasible since there could be strong waves that could cause the water to come on the boat which could spoil the device. Moreover, AirPi does not display the data it obtains but rather uploads it to the internet. This can be a problem for the fishermen since they need to use a mobile phone or laptop with a working internet connection to be able

[1] Apple Inc., available at: https://www.apple.com/ios/siri/

[2] Samsung, available at: http://www.samsung.com/global/galaxy/what-is/s-voice/

[3] Microsoft Windows, available at: http://www.windowscentral.com/cortana.

to access this data. Nonetheless, the requirement of a working internet connection also makes it hard to use this device at sea.

As such, with limited personal assistants available to support small scale fishermen during fishing activities at sea or in lakes, further work is the area is still needed. Taking cognizance of this gap, this paper investigates the implementation and deployment of a low-cost Raspberry Pi based personal assistant for small-scale fishermen, through a proposed device named JarPi. Implementation of JarPi is discussed in the next section.

II. JarPi

In order to address the problem pertaining to the lack of personal assistants for small scale fishermen, a low-cost solution named JarPi was designed and implemented. JarPi is a Raspberry Pi based personal assistant particularly meant to help fishermen during fishing activities by giving various information including position (latitude and longitude), distance and direction from shore, wind speed, temperature, humidity, rainfall amount and air pressure, amongst other factors. It has been set up on Raspbian Jessie operating system and relies on various sensors in order to sense environmental factors. For communication with the RPi, the weather related sensors were connected to a wireless transmitter that in turn communicates with a wireless receiver connected to the Raspberry Pi via USB. This was done so as to simplify communication between devices thus also making troubleshooting easier. Furthermore, the weather station can be clamped on top of the boat at the corner while having the RPi component (covered in a waterproof container) being nearer to the fishermen. The circuit diagram showing the interconnection of the various components of JarPi is illustrated in Fig. II.

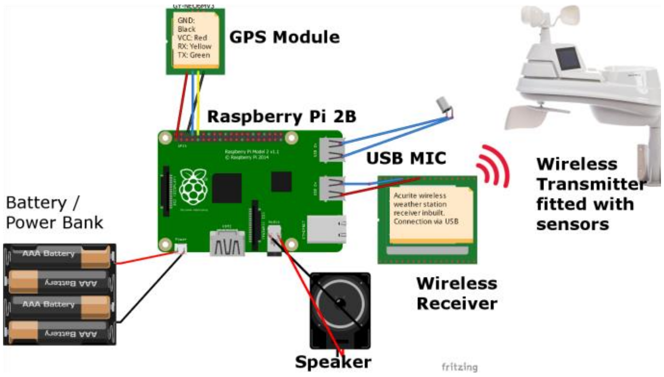

Fig. II - Circuit Diagram of JarPi

In terms of technical specifications, JarPi is powered by a battery supplying 5v 2A of power. A GPS module is also present which is used to get the location of the fisherman (latitude and longitude) and the distance travelled from the shore. This module is connected to the GPIO pins as shown in Table I. Furthermore, Raspberry Pi makes use of the Universal Asynchronous Receiver/Transmitter (UART) for serial console through pins 8 and 10. This functionality had to be turned off to make use of these pins although this was not a straight forward task as the newer version of Raspbian Jessi uses system instead of the init system. As such, the kernel had to be first modified to use the init system and then, the serial console was disabled to allow use of the pins for GPS module. The main language used for the implementation of JarPi was C.

Table I - Pin connection details

MODULE	GPIO PIN
VCC	1
GND	6
TX	8
RX	10

To facilitate interaction, JarPi is operated using voice commands so also reduce physical touch with the device while at sea or in lakes. This was done so that fishermen can interact with JarPi while also being able to perform their fishing activities. Furthermore, by using such interaction approach, fishermen only need to learn the voice commands thus also improving learnability. For the implementation of voice-based interaction, a microphone was connected to the RPi via USB. Also, a self-powered speaker was connected through the 3.5mm audio jack as output device to provide appropriate responses to commands given by the fishermen. The speech to text library used by JarPi is Pocketsphinx[4], which is an open source speech synthesizer. The main advantage it has over other speech to text engines is that it works offline which is of critical importance to the fishermen when at sea although its accuracy is lesser as compared to online engines. To address this issue, a dictionary file was created using lmtool[5] and the program was then made to start using the created dictionary file instead of the standard one provided by Pocketsphinx. This measure also helped to bring down the inaccuracy levels to a high extent. On the other hand, the text to speech engine used by JarPi is eSpeak[6] which is an open source tool which requires Python 3 to run which also had to be installed on the Raspberry Pi. In essence, eSpeak was used to read out the data collected from the sensors, which are also archived in XML files. The key commands that can be given by fishermen during interaction with JarPi along with the responses are given in Table II, where values in square brackets represent data retrieved from sensors or computed data.

Table II – Voice Commands and Associated Responses

Command	**Response**
Jarvis	Jarvis activated. Waiting for your command.
Hello	Hello
How are you?	I am doing well. Thank you for asking
Wind Speed	The current Wind Speed is [WINDSPEED]
Wind Direction	The wind is blowing towards [WINDDIRECTION]
Temperature	The current temperature is [TEMPERATURE]
Humidity	The current Humidity is [HUMIDITY]

[4] Pocketsphinx, Available at: https://github.com/cmusphinx/pocketsphinx
[5] lmtool, Available at: http://www.speech.cs.cmu.edu/tools/lmtool-new.html
[6] eSpeak, Available at: http://espeak.sourceforge.net/

Rainfall	The current rainfall measurement is [RAINDALL]
Average Wind Speed	The average wind speed is [AVGSPEED]
Average Temperature	The average temperature is [AVGTEMP]
Average Humidity	The average Humidity is [AVGHUMID]
Average Rainfall	The average Raindall is [AVGRAIN}
Time	The current time is [TIME]
Time Spent	You have been [TIMESPENT] in the ocean
Date	The date is [DATE]
Distance from shore	You are [DISTANCE] from the shore
Play Music	[Random music from playlist being played]
Stop Music	[Music stops]
Shutdown	Shutting down. Thank you for using JarPi

Finally, to implement JarPi, approximately $175 was spent consisting of the RPi, relevant sensors, speaker and microphone thus also highlighting the low overall cost of the solution, which might be further decreased during bulk production. The implemented solution is as depicted in Fig. III.

Fig. III – JarPi

III. EVALUATION

In order to understand the user experience of fishermen when using JarPi, an experiment involving this target group was conducted. Particularly, the usability of JarPi was assessed because if the system is difficult to use, adoption rate will be significantly reduced [9]. Based on Nielsen's principles, usability is principally defined by 5 quality components, namely, learnability, efficiency, memorability, errors and satisfaction [9], which were considered when evaluating JarPi. Additionally, affordability, intention to use and ease of use were also considered to obtain insightful information on future adoption of the system. As evaluation method, a combination of cognitive walkthrough and cooperative evaluation was adopted. With cognitive walkthrough the evaluators have to perform a series of tasks before eventually asking questions from the perspective of the end user. Since users often tend to remain quiet when confused and for this reason, cooperative evaluation, which is also a variant of think-aloud was chosen. This approach gave the participants the opportunity to explain what is being done and why in addition to asking questions so that same could be clarified early.

For evaluation, the targeted participants were small-scale fishermen due to the application scope of JarPi. Rather than lab-based evaluation, field-based assessment at Lake Victoria in Uganda was conducted for in-depth analysis and to also get more insightful information on underlying challenges [10]. On the shores of the lake, 23 fishermen who were fluent in English were recruited as JarPi only supported commands in this language. Another less important factor that was taken into consideration was whether the fishermen were acquainted with any IT based personal assistants. If so, these fishermen were to be recruited first due to their basic knowledge of what JarPi would be used for. Unfortunately, none of the small scale fishermen were familiar to such personal assistants.

In terms of procedures, once a fisherman was recruited, a short training on the purpose of the research was given following ethical consent of the participant. Then, JarPi was installed in the respective boats of the participants and the participant could go on performing their fishing activities, whilst also interacting with JarPi while executing commands given in Table II. At the same time the queries and clarifications sought by participants were treated and also audio recorded by the research team. Following completion of the tasks during the same day, the participants had to fill-in a pre-formulated questionnaire to collect data on the usability on JarPi. Finally, the collected data (from questionnaire and audio recordings) were analysed statistically.

IV. RESULTS AND DISCUSSIONS

Although it was not a part of the criteria set for recruiting participants, only male fishermen participated in the study mainly due to familiarity with the English language. There was also a varied age group amongst the fishermen where 5 of them were new, also falling in the age group 18-24. This group had up to 3 years in terms of fishing experiences. The rest of the fishermen aged between 25 and 35 years with up to 18 years fishing experience for some. During the recruitment, it was also found out that none of the fishermen ever used a personal assistant while fishing and this were due to various reasons including awareness of their existence and affordability, accessibility, among other reasons. The experimentation results are compiled in Table III, where for each criterion, a Likert-5 scale was utilized where 1 represents highly disagree and 5 represents highly agree.

Table III – Results

Quality component	Avg. Score
Perceived ease of use	
There was no need for an accompanying expert when using the system.	**3.5**
The system was easy to use	**4.5**
I felt very confident when using the system.	**4.1**
Perceived Enjoyment	
The overall experience was enjoyable	**4.2**
Intention of use	
I would like to use this system again.	**4.7**

Learnability	
The system did not require me to learn additional skills	**3.2**
I would imagine that most people would learn to use this system quickly.	**3.9**
Efficiency	
The system was efficient in providing needed information.	**4.0**
Memorability	
The system did not require me to remember many things.	**3.5**
Satisfaction	
I was satisfied with the system	**4.0**
This system has all the functions and capabilities I expect it to have.	**4.5**
Errors	
There were no major barriers when using the system	**3.7**
Affordability	
I can afford to buy this system	**3.8**

For the perceived ease of use of the system, a positive average score of 4.0 was obtained. Although the fishermen perceived that the system was easy to use, a relatively lower score was obtained for the need for an accompanying expert when using the system. Since the fishermen were not well acquainted with the use of fishing-based personal assistants, a group mentioned that accompanying experts for the first time of use could be supportive. Similarly, it was observed that the confidence level of participants gradually increased when utilising JarPi, where in the beginning, many fishermen were not sure how the device would respond but at the end of the experiment, commands were being given without hesitation. Furthermore, participants also found the overall experience enjoyable where many highlighted that it was new to have a talking assistant to them that provides useful information when needed. This is possibly why the highest score was obtained for the intention to use the system again in the future. As compared to the other quality components studied, the average learnability of JarPi was found to be relatively lower, with an average score of 3.6 where many participants highlighted the need to learn additional skills especially for manipulating the device, which was new to them. Similar to memorability, the major concern in terms of learning and remembering was the commands for interacting with the system. As the participants were also using the system for the first time, the command list had to be used for reference and there were various times when fishermen tried other keywords, which JarPi obviously did not give any meaningful response. On the other hand, the voice based interaction was also appraised by the participants, which helped to improve learnability as the fishermen had limited touch-based interaction JarPi. As for efficiency, although interaction was smooth for most participants, JarPi had trouble recognising the speech of 2 participants. This was especially due to accent challenges but after the user tried 2-3 times, the system could interpret the commands and provide appropriate responses. Moreover, the error rate was also positive with no significant barrier mentioned. Whilst JarPi was only available in English and cultural disbeliefs of some users in using IT tools at sea, few participants thought that using IT tools at the lake is risky and could spoil the device due to water. However, the doubts were clarified where confidence and comfortability of using JarPi in the lake increased during the experiment as mentioned earlier. Additionally, a high satisfaction rate was also noted during the experiment similar to a positive affordability rate. 78.3% participants agreed or strongly agreed that JarPi was affordable, and this could be attributed to its build-up using Raspberry Pi. The rest of the participants neither agreed nor disagreed and this was particularly due to their other commitments, thus impacting the affordability score.

Overall, an average score of 4.0 was obtained for the quality components analysed during the experiment. The highest scores were obtained for intention to use JarPi in the future again and user satisfaction thus also highlighting the prospects of such applications for fishermen. On the other hand, a relatively lower score was obtained for memorability and this was principally due to the need for having to remember the commands for successful interaction with JarPi. The distribution of the average scores for the different quality components analysed is given in Fig. IV.

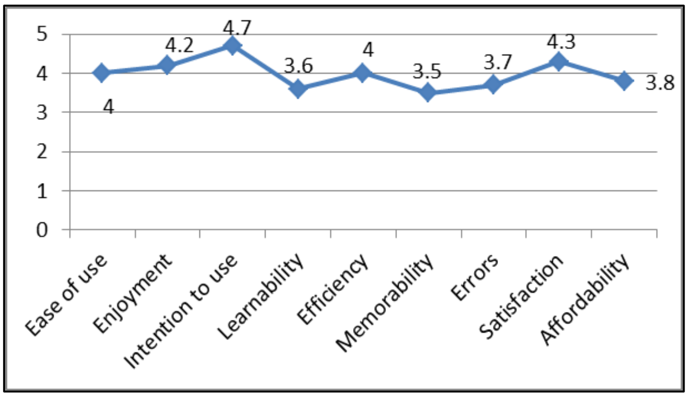

Fig. IV – Average Scores of Quality Components

The experiment also helped to identify various challenges of using a Raspberry Pi based personal assistant. These challenges in addition to potential solutions are:

- ***Language related barriers***
  As JarPi only understood English based commands, its large scale deployment would be challenging due to the fact that not all fishermen are conversant and fluent in speaking English. As such, local and other international languages could be considered in future implementations. Furthermore, there were cases were JarPi was not able to understand the fishermen's accent on multiple occasions and commands had to be repeated. To address this issue, a speech recognition training algorithm could be implemented.

- ***Noise from surroundings***
  During the experiment, it was also noted that noise from the surroundings due to windy conditions and waves affected the interaction between the fishermen and JarPi. This disturbance can be more significant bad weather conditions. To better study these disturbances, further experimentation could also be conducted in sea and other fishing regions

with varying weather conditions and surroundings. As a solution to such disturbances, JarPi could be further shielded and brought closer to the fishermen. Otherwise, a Bluetooth microphone or headset could also be connected to JarPi to smoothen interaction.

- ***Limited command list***

With the proposed version of the personal assistant, a few fishermen highlighted that a limited number of commands were available. Some fishermen proposed further features related to location, water-related parameters, forecasting on fish population, sun position, historical data on fish catch, emergency calls, amongst other aspects. Such features could be further studied and implemented in the next version of JarPi. However, the inclusion of further sensors and features could impact the affordability of the tool.

- ***Spoken commands v/s fish catch***

One of the fishermen also raised the point that the interaction technology utilized by JarPi could affect fish catch. Spoken commands and voice from the speaker could be a warning sign to fishes thus reducing fish catch. Although this hypothesis needs further experimentation, potential solution could involve the use of headsets to reduce emitted sounds from JarPi.

- ***Battery dependence***

Even though Raspberry Pi consumes relatively low power [11], the battery of JarPi could be depleted after long usage. In case proper measures are not taken (e.g. spare batteries), the tool could remain unavailable especially during long fishing sessions. As a solution, solar-based charging systems could be investigated and implemented within JarPi.

V. CONCLUSIONS AND FUTURE WORKS

In order to address the occupational safety hazards that small-scale fishermen face due to unavailability of real-time weather information during fishing activities at sea, this paper investigated the implementation and deployment of a low-cost Raspberry Pi based personal assistant for small-scale fishermen, through a proposed device named JarPi. This device has embedded features to help fishermen during fishing activities by giving various information including position (latitude and longitude), distance and direction from shore, wind speed, temperature, humidity, rainfall amount and air pressure, amongst other factors. To facilitate interaction, JarPi is operated using voice commands so also reduce physical touch with the device while at sea or in lakes.

In order to understand the user experience of fishermen when using JarPi, an experiment involving 23 small-scale fishermen was conducted in Lake Victoria (Uganda). The experiment revealed an overall positive user experience with JarPi with the highest scores obtained for components including the intention of using the tool again in the future, perceived enjoyment and user satisfaction. The positive results obtained for these aspects also highlight the prospects of JarPi for assisting small-scale fishermen to obtain key weather related information instantaneously. Contrarily, a relatively lower score was obtained for memorability and this was principally due to the need for having to remember the commands for successful interaction with JarPi. As future work, the solutions to the limitations identified during experimentation would be addressed to build-up and deploy JarPi 2.0 on a large scale.

VI. REFERENCES

[1] E. Allison, A. Perry, M. Badjeck, W. Neil-Adger, K. Brown, D. Conway, A. Halls, G. Pilling, J. Reynolds, N. Andrew and N. Dulvy, "Vulnerability of national economies to the impacts of climate change on fisheries," *Fish and fisheries,* vol. 10, no. 2, pp. 173-196, 2009.

[2] N. Sobania, "Fishermen herders: Subsistence, survival and cultural change in Northern Kenya," *The Journal of African History,* vol. 29, no. 1, pp. 41-56, 1988.

[3] O. Jensen, "Health hazards while fishing in heavy weather," *Occupational and environmental medicine,* vol. 54, no. 2, p. 141, 1997.

[4] I. Kaplan and H. Kite-Powell, "Safety at sea and fisheries management: fishermen's attitudes and the need for co-management," *Marine Policy,* vol. 24, no. 6, pp. 493-497, 2000.

[5] F. Percin, O. Akyol, A. Davas and H. Saygi, "Occupational health of Turkish Aegean small-scale fishermen," *Occupational medicine,* vol. 62, no. 2, pp. 148-151, 2011.

[6] Raspberry Pi Foundation, "What is a Raspberry Pi?," Raspberry Pi Foundation, 2014. [Online]. Available: https://www.raspberrypi.org/help/what-is-a-raspberry-pi/. [Accessed 6 Jan 2016].

[7] L. Upton, "Five Million Sold!," Raspberry Pi Foundation, 18 Feb 2015. [Online]. Available: https://www.raspberrypi.org/blog/five-million-sold/. [Accessed 17 Jan 2016].

[8] T. Hartley, "AirPi Air Quality & Weather Project," Airpi.es, 2016. [Online]. Available: http://airpi.es/. [Accessed 19 May 2017].

[9] J. Nielsen, Usability 101: Introduction to usability, 2003.

[10] B. Fogg, Persuasive technology: using computers to change what we think and do, Morgan Kaufmann, 2002.

[11] G. Bekaroo and A. Santokhee, "Power consumption of the Raspberry Pi: A comparative analysis," in *IEEE International Conference on Emerging Technologies and Innovative Business Practices for the Transformation of Societies (EmergiTech),* 2016.