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Feasibility Study on Using Smartphones via Bluetooth for Commanding Buffalos

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***Abstract*:** Thai water buffalos (*Bubalus bubalis*) or krabue (in Thai) are native animals that play an essential role in the traditional way of life of Thai farmers, especially in farming processes, including tilling soil in preparation for planting, providing manure to be used as fertilizer, and dragging carts to carry rice, among other tasks. To the farmers, therefore, water buffalos are an important part of their team and are even considered to be like their family members. Nowadays, the use of a two-wheel type of tractor is increasingly replacing buffalos because they are more convenient and better able to serve mass production needs. However, when the economic situation changes and the price of oil and the cost of living both increases, farmers return to using buffalos in their farming activities in line with the sufficiency economy theory. Therefore, this research aims to improve the standard of living of Thai farmers by studying the possibility of using modern technology and innovations in the form of smartphones operated via Bluetooth to command the buffalos to move in the desired direction. A prototype system was developed for commanding buffalos to work for farmers. The results show that the buffalos tend to comply with the commands from the developed equipment. However, the equipment still requires further development.

***Keywords*:** Buffalos, Commanding, Smartphones

Water or swamp buffalos are mainly found in East and South Asia and represent 20.51% of the world's total buffalo population (Cruz 2013). Drought-adapted water buffalo provide meat and highly nutritious milk that can be used to make cream, butter, yogurt, and cheese. Knowledge about the water buffalo gives farmers the power to improve the sustainability, efficiency, and profitability of their production (Cruz 2012, Hazem et al 2019). When buffalos produce offspring, they increase the household assets that can be rented out in exchange for either cash or nonfinancial assets and services (Bonnin 2015). In Cambodia, these animals are concentrated in rice-growing areas, with cattle and buffalo predominantly kept to provide power for soil preparation, weeding, harvesting, and transportation as well as to provide manure rather than being bred for meat production (Sokerya et al 2010). Indeed, nearly 80% of farmers raise buffalos as a source of power for work (Sarakul et al 2016). Thai water buffalos can be trained to work in many farm activities such as plowing, raking, or dragging while they can also be ridden as a form of transport. However, the role of water buffalos in farming has been increasingly neglected by the government and even by farmers as they are replaced by two-wheel tractors. In both lowland valleys and highland terraces, two-wheel tractors, known in the Thai language as 'Iron buffalos', are increasingly used for plowing rice fields (Rigg 2003). Studies indicate that two-wheel tractors are relatively cheap to buy and operate as well as being more convenient and efficient for tilling than buffalos. As farmers use ever-increasing amounts of chemical fertilizers, buffalo dung also plays a lesser role in maintaining soil fertility than in the past (Jean-François Rousseau and Janet Sturgeon 2019). Only when farmers are faced with higher costs of living and oil prices are water buffalos considered to be of use again (Table 1).

The of training buffalos for plowing is important. Buffalos can be trained from between 2-3 years old. At this age, the buffalos are beginning to have strong muscles and can pull the plow but can be controlled easily. Before training, buffalos should be strong-looking, with strong legs and hooves. When they walk, the rear foot should cross the front foot at each step. Requires the use of a rope passed through the septum of the buffalo's nose. The rope should be passed indirectly under the ear and tied at the back of the neck with a dead knot at the appropriate tautness (not too tight or too loose). Another rope tied around the neck will be used as a means of controlling the carrying rope. It should not be loose over the front of the ear, as this will loosen the rope and make it difficult to control the buffalo and may be dangerous to the buffalo if it steps on the nose rope. Training the buffalos to know the commands is an important step in the training of Thai water buffalos (Table 2). The method used in other countries is tail twisting (Gregory et al 2009). The tail and the nose of the bovine are well innervated, and it is recognized from clinical practice that they are sensitive to a range of potentially painful stimuli. The nose rope command is based on the principle of applying pressure to a sensitive part of the buffalo. This makes the buffalo more tractable and more easily led by hand when the nose rope is pulled (Alam et al 2010). For the voice commands used to communicate with the buffalos, they depend on the person doing the training and which local commands are normally used to make the buffalos understand the command. The objective of this feasibility study is to explore the use of smartphones via Bluetooth for commanding buffalos to move in the desired direction. The methods employed for commanding buffalos may also be applicable to other trainable animals with good learning skills. This technology has the potential to replace two-wheel tractors in a rice field with buffaloes.

MATERIAL AND METHODS

The operation system design of the control equipment used to study the feasibility of using a smartphone via a Bluetooth controlled device for commanding buffalos is summarized in Figure 1.

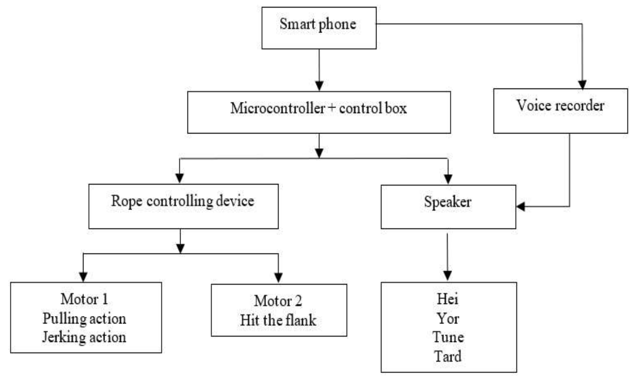

Fig. 1. Schematic diagram of using smartphone via Bluetooth for commanding buffalos

Table 1. Comparison between two-wheel tractors and buffalos (Department of Livestock at Wang Noi District and Non-Formal Education Centre at Wang noi 2016)

Topics	Two-wheel tractor	Buffalo
Price	700 - 1,400 USD*	270 - 500 USD
Lifetime	Main structure 5 -7 Yrs. Engine 8-10 Yrs.	25 - 30 Yrs.
Cost during work	Fuel cost	Nothing
Working hours	8 -10 hrs./day	4 - 6 Hrs./day
Efficiency	0.48 – 0.8 ha/day	0.08 – 0.16 ha/day
When expired	Out of service, sold as scrap metal	Dies, sold as meat
Size of land that can be farmed	Suitable for more than 3.2 ha	Suitable for 0.48 - 1.6 ha
When not using to plow	Used as farm truck, deteriorates, continuously requires expenses for maintenance	Used with cart as farm tuck, can produce baby buffalos
Operator	Strong man	Man, woman, teenager
Waste product from usage	Engine oil makes soil pollution	Produces manure (Shirai and Yokoyama 2014)

* Average 8-14 Hp Price including of engine, main structure and cage wheel

Table 2. Examples of rope and voice commands to buffalo

Action	Wang Noi District, Khon Khen Province (North-east province of Thailand)		Suphanburi Province (Central province of Thailand)	
	Rope	Voice	Rope	Voice
Move forward	A well-trained buffalo may not require the use of a rope and can be controlled by voice commands only.	Pai	The other end of the rope is used to hit the flank of the buffalo	Hei
Stop		Yor	-	Yor
Turning left		Leaw	Pull	Tune
Turning right		Tok	Jerk	Tard
Move backward (When plowing stuck to a stumps)		Hon	Push from the front	-

The smartphone via Bluetooth control device for commanding buffalos consists of 1) software on a smartphone (HTC model Desire C), 2) a control box with microcontroller AT89C2051, 3) voice recording equipment, 4) speakers 15 Watt, 5) a 12 VDC battery, 6) a nose rope, 7) a main structure, 8) a controlling unit for turning the buffalo, and 9) a controlling unit for move forwarding the buffalo (Fig. 2).

When pressing the right arrow icon on the smartphone to make the buffalo turn right, the motor will spin to twitch the rope, and the speaker will play a 'tard' sound, prompting the buffalo to turn right. The twitching mechanism is similar to the crankshaft rotation. When pressing the left arrow icon on the smartphone to make the buffalo turn left, the motor will spin to pull the rope, and the speaker will play a 'tune' sound, prompting the buffalo to turn left. A specific time is set, after which the motor will spin in the opposite direction to release the tow rope in order to maintain the same rope distance. When pressing the up-arrow icon for the buffalo to move forward, the motor that controls the buffalo to move forward will spin like a seesaw; the small iron rod will hit the flank of the buffalo to command it to move forward, and the speaker will play a 'hei' sound, prompting the buffalo to move forward. When pressing the back-arrow icon to go back or to stop the buffalo, the speaker will play a 'yor' sound, prompting the buffalo to stop.

The study was conducted at the Thai Buffalo Conservation Village, Suphan Buri Province. The experiment conditions were as follows: 1. the buffaloes that were used in this experiment had to have been trained beforehand (Table 3). 2. Buffalos participating in the experiment were not equipped with plowing equipment; and 3. Control distance was limited to not more than 10 meters depending on the Bluetooth signal power. The experiment focused on controlling buffalos using voice and nose rope commands, with eight different tests repeated ten times each. The reactions of the buffalos to the commands were recorded, and then the results were compared in percentages. The details of the buffalos used in the experiment are shown in Table 3. The three buffalos used in the experiment named Sao (B1), Peuk (B2), and Suk (B3) were aged 17, 15, and 12 years old, respectively (Fig. 3). These buffalos started being trained using voice and nose rope commands at the age of three. The authors took three days to become familiar with the buffalos before the experiment. The test methodology is shown in Table 4.

RESULTS AND DISCUSSION

The results show that when using nose rope commands only, voice commands only, and nose rope commands

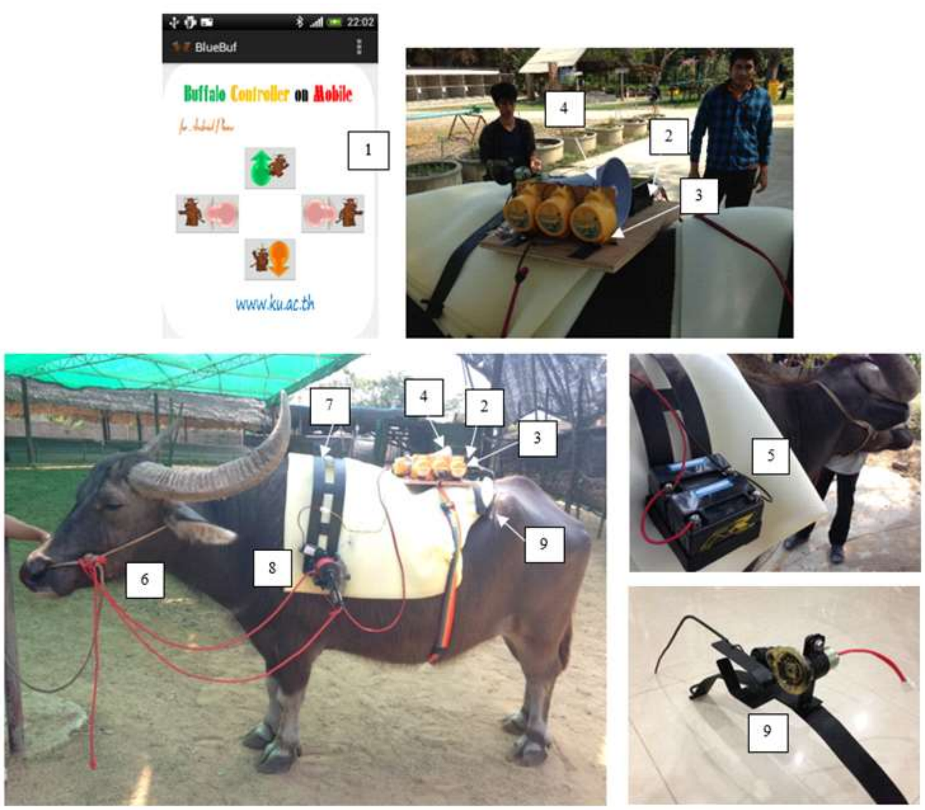

Fig. 2. Smartphone via bluetooth control device for commanding buffalos

together with the voice commands of the buffalos' owners to control the buffalos, all of the buffalos were able to perform 100% of the commands (Table 5). When using the voice of other people (the research team) rather than the owners' to control the buffalo, the average success rate for the commands to go forward and to stop was 73.34%. When testing the effectiveness of the nose rope commands from the developed equipment to control the buffalos, the results show

Fig. 3. Buffalos used in this experiment

Table 3. Buffalos used in this experiment

Name	Age (Years)	Trained since (Age)	Habits
B1	17	3	Docile, friendly, fast learner
B2	15	3	Docile, friendly
B3	12	3	Alert, stubborn

Table 4. Methods of buffalo commanding

Test	Methods of buffalo commanding	Operator
1	Testing of nose rope commands to control the buffalo	Buffalo's owner
2	Testing of voice commands to control the buffalo	Buffalo's owner
3	Testing of another person's voice to control the buffalo	The research team's voices after being trained by the buffalo's owner
4	Testing of nose rope commands together with voice commands to control the buffalo	Buffalo's owner
5	Testing of nose rope commands to control the buffalo	The developed equipment
6	Testing of voice commands to control the buffalo	The developed equipment with the owner's recorded voice
7	Testing of voice commands to control the buffalo	The developed equipment with another person's recorded voice (The research team's voices after being trained by the buffalo's owner)
8	Testing of nose rope commands together with voice commands to control the buffalo	The developed equipment with the owner's recorded voice

Table 5. Test results of using smartphone via Bluetooth for commanding buffalos

Test	Compliance with buffalo commands (%)															
	B1				B2				B3				Average			
	Go forward	Stop	Turn left	Turn right	Go forward	Stop	Turn left	Turn right	Go forward	Stop	Turn left	Turn right	Go forward	Stop	Turn left	Turn right
1	100	0	100	100	100	0	100	100	100	0	100	100	100	0	100	100
2	100	100	0	0	100	100	0	0	100	100	0	0	100	100	0	0
3	80	80	0	0	80	80	0	0	60	60	0	0	73.34	73.34	0	0
4	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
5	10	0	10	10	20	0	20	20	10	0	10	10	13.34	0	13.34	13.34
6	80	80	0	0	80	80	0	0	80	80	0	0	80	80	0	0
7	50	50	0	0	50	50	0	0	40	40	0	0	46.67	46.67	0	0
8	80	80	0	0	70	70	0	0	60	60	0	0	70	70	0	0

1: Nose rope commands to control the buffalo (tested by the owner), 2: Voice commands to control the buffalo (tested by the owner)
3: Another person's voice commands to control the buffalo (tested by the research team), 4: Nose rope commands together with voice commands to control the buffalo (tested by the owner)
5: Nose rope commands to control the buffalo (tested by the developed equipment), 6: Voice commands to control the buffalo (tested by the developed equipment with the recorded voice of the owner)
7: Voice commands to control the buffalo (tested by the developed equipment with the recorded voice of another person), 8: Nose rope commands together with voice commands to control the buffalo (tested by the developed equipment with the recorded voice of the owner)

that the buffalos were able to comply 13.34% of the time for the commands to turn left and to turn right. The results of using the developed equipment with the recorded voice commands of the owners to control the buffalos revealed that the buffalos were able to comply with the commands 80% of the time for the go forward and the stop commands. Using the developed equipment with the recorded voice commands of other people, rather than the owners, the success rate for the 'go forward' and 'stop' commands was 46.67%. Using the developed equipment with the owners' recorded voice commands, the buffalos were able to comply with the commands 70% of the time for the 'go forward' and 'stop' commands. The buffalos were able to understand the voice commands from their owners' very well, especially the go forward and stop commands (Table 5). The buffalos also understood voice commands when they were made by unfamiliar voices. It is possible that the buffalos are most familiar with go forward (*hei)* and stop (*yor*) voice commands because they hear them frequently, and they are easy to follow. For the turning commands, the buffalos did not obey the commands, whether they were made by their owners or unfamiliar voices. They turned their head to the requested direction but did not move, indicating a degree of understanding. When comparing the buffalos' responses to voice commands made by their owners and those made by unfamiliar voices, the buffalos followed their owners' voice commands better than those made by unfamiliar voices. This is likely because the buffalos are familiar with the voices of their owners. However, the buffalos that took part in the study had been trained and worked for a long time and had likely been handled by many caretakers making it easier for them to get accustomed to other people's voices and comply with commands made by unfamiliar voices as well. When comparing between real voices and the recorded voices played through the speakers, buffalos were better able to follow the real voices than the recorded ones. This may be because the quality of the sound from the speakers is not good enough. It is possible that either the buffalos could not hear the voice commands clearly or they could hear them, but because the recorded voice commands were different from those of their owners and did not follow the commands. However, if the sound's quality is improved, then the results may be as good as those made by real voices.

For the nose rope commands made by the owners the buffalos could comply in 100% of cases for all three commands: go forward, turn left and turn right. This may be because the buffalo's noses had been pierced in the right position, which made it easy to control them, and also the buffalos have been well trained, are highly experienced, and have worked for a long time. Otherwise, the difficulty in commanding the buffalos in this way would be known as “hard nose” behavior. When giving commands to turn left and right, the nose rope was pulled or jerked to stimulate the buffalos, causing them immeasurable pain then and motivating them to follow the commands. In the case of moving forward, a hand or the other end of the nose rope is used to hit the buffalos on their left flank to make them move forward and follow the command. From using only nose rope commands by the developed equipment to control the buffalos to turn left (pulling on the rope), the buffalos complied with the commands to turn left on 13.34% of the cases. This is due to the developed equipment's action of pulling and releasing the nose rope not being the same as when the owner pulls on the rope, resulting in the buffaloes not following the commands. The results of the commands by the developed equipment to turn right (jerking the rope) also produced a 13.34% success rate. For the command to go forward, the developed equipment used a steel bar to hit at the left flank of the buffalos, but it was found that the action may have been too soft due to the buffalos having thick skin. According to Muralidharan and Ramesh (2005), the papillary and reticular layers of the Murrah buffalos hides measured 1.18±0.06 mm and 4.91±0.06 mm, respectively while the thickness of the epidermis of the buffalo's skin was 6.16±0.27 μ which is considerably thicker compared to the skin of a cow or camel (Saffia Kareem Wally Al- Umeri and Nabeel Abd Murad Al- Mamoori 2016). Therefore, it is likely that the buffalos did not feel anything when they were hot gently with the bar and did not follow the commands. In testing the developed equipment, the results of using nose rope commands together with voice commands made by the owner's recorded voice to control the buffalos revealed that the buffalos were able to comply with the go forward and stop commands to a favorable degree (70%). This may be because of the sound of the owner's recorded voice played through the speaker being familiar to the buffalos together with their compliance with the commands to turn left and right for the reasons mentioned above.

CONCLUSION

Right up to the present, Thai water buffalos still play an important role in the agricultural production processes of many smallholder farmers, especially in rural areas. It is possible to control buffalos using a smartphone via Bluetooth to commanding them to move in the desired direction, it is necessary for the buffalos to be trained to use the equipment from a young age to enable them to become familiar with the equipment and follow the commands successfully. This same idea may apply to any animals that can be trained and have good learning skills.

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