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Short paper

Video characteristics for remote recognition of agonal respiration: A pilot study

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Abstract

Aim: The mobile network quality in ambulances can be variable and limited. This pilot study aimed to identify a suitable network setting for recognizing agonal respiration under limited network conditions.

Methods: We recruited five emergency medical technicians, and each participant viewed 30 real-life videos with different resolutions, frame rates, and network scenarios. Thereafter, they reported the respiration pattern of the patient and identified agonal respiration cases. The time at which agonal respiration was identified was also recorded. The answers provided by the five participants were compared with those of two emergency physicians to compare the accuracy and time delay in breathing pattern recognition.

Results: The overall accuracy for initial respiratory pattern recognition was 80.7% (121/150). The accuracy for normal breathing was 93.3% (28/30), for not breathing was 96% (48/50), and for agonal breathing was 64.3% (45/70). There was no significant difference in successful recognition between video resolutions. However, the rate of time delay in recognizing agonal respiration less than 10 seconds between 15-fps group and 30-fps group had statistical significance (21% vs 52%, $p = 0.041$).

Conclusion: The frame rate emerges as one of critical factors in agonal respiration recognition through telemedicine, outweighing the significance of video resolution.

Keywords: Video, Agonal breathing, Telemedicine

Introduction

Agonal breathing is an important recognizable characteristic for lay rescuers or paramedics to initiate cardiopulmonary resuscitation (CPR).[1,2] It occurs in approximately half of the out-of-hospital cardiac arrest (OHCA) patients.[1] However, there is no single descriptor for lay rescuers to recognize agonal breathing, and it is often identified as abnormal breathing, snoring, or gasping.[3,4] Hence, agonal breathing is sometimes not recognized by lay rescuers or inexperienced prehospital personnel, and the initiation of resuscitation is delayed.[5] Most previous studies have focused on training paramedics to recognize agonal respiration in the field,[6–9] whereas few have explored the potential utility of telemedicine in respiratory pattern recognition.[10,11]

The quality of real-time video streaming in an ambulance significantly depends on the available mobile network bandwidth. Moreover, in such mobile scenarios, maintaining streaming quality is challenging because it often varies owing to multipath fading and shadowing effects. Currently, bitrate adaptation is a common method for providing a high-quality user experience in video streaming under constantly changing network conditions.[12] It involves a trade-off between the image quality and video smoothness. However, most adaptive bitrate algorithms, such as those adopted by Netflix and YouTube, are used for entertainment purposes, to avoid viewers from turning off the videos due to poor visual experience. No previous video streaming algorithm has been proposed for respiratory recognition. Therefore, this pilot study aimed to investigate the influence of videos with different resolutions and frame rates on agonal breathing recognition by emergency medical technicians (EMTs)

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under various network conditions, and provide guidance for the future design of video streaming algorithms for remote emergency care.

Material and methods

Study design

This study was designed to investigate the accuracy of recognizing agonal breathing under limited network conditions and was approved by the Institutional Review Board of the National Taiwan University Hospital and carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki).

Study population and data collection

Five in-service EMTs were recruited, including three intermediates and two paramedics (Taiwan grading system).[13] Baseline demographic characteristics were reported by the participants, including age, gender, years of experience as a EMT and times of rescuing OHCA patients in the three month before the study. After getting informed consent from the patients or their next of kin, 30 real-life videos of different patients in an ambulance, ranging from 4–7 min, were shown to the participants. They were asked to report the initial breathing pattern and the time at which the breathing pattern changed. These 30 videos were independently viewed by two emergency physicians, who verified that they comprised 6 videos of patients with normal breathing, 10 of patients that were not breathing, and 14 of patients with agonal breathing. If any concerns arose during the video review, the two physicians would engage in a discussion and reach a consensus. These videos were streamed in eight different settings with combinations of four different resolutions (720p, 480p, 360p, and 240p) and two frame rate settings (15 and 30 frame per second [fps]) over network conditions emulating a mobile network.

The simulated network conditions included three scenarios. The first two were composed of good network streaming and intermittently reduced network settings, whereas the third emulated a poor network condition (Table 1):

(1) A good network scenario with less delay, jitter, and burst packet loss.
(2) A good network scenario with less delay and jitter, but intermittent burst packet losses and reduced bandwidth, simulating mobile network variations within ambulances.
(3) A poor communication channel with a large delay, jitter, and packet loss rate.

All 240 videos (30 videos each at eight different resolutions and frame rate settings) were streamed using the VideoLAN Client (VLC) media player and recorded by the streaming client. For each participant, we streamed ten videos with different content under one of the previously mentioned network scenarios, that is, (1), (2), or (3). Thirty videos were presented to each participant, who reported the initial and other breathing patterns throughout the video.

Outcome measurement

The answers provided by the five participants were compared with those of the two emergency physicians to compare the accuracy and delay in breathing pattern recognition.

Statistical analysis

In each group, categorical variables were presented with descriptive statistics such as frequencies and proportions. Continuous variables were summarized using measures such as means or medians. Categorical variables were analyzed with the Chi-square test or Fisher's exact test. A p-value of less than 0.05 was considered statistically significant. Statistical analyses were performed using R (version 4.3.0; R Foundation for Statistical Computing, Vienna, Austria).

Results

The mean age of the five participants was 37 years, with an average of 12-year-experience as an EMT and an average of 5.6 cases of rescuing OHCA patients in the 3 months prior to this study. Each participant viewed the 30 adjusted videos under different network scenarios. The overall accuracy for initial respiratory pattern recognition was 80.7% (121/150). The accuracy was 93.3% (28/30) for normal breathing, 96% (48/50) for not breathing, and 64.3% (45/70) for agonal breathing. Among the 70 video clips in which patients exhibited agonal breathing, 9 were reported as normal breathing and 16 were reported as not breathing. The answers for each breathing scenario and overall successful recognition rates by different scenarios are summarized in Fig. 1. The success rate and average time delay for each participant are listed in Table 2. Participant 3 had the lowest successful recognition rate.

In Table 3, we conducted a comparative analysis of the successful recognition rates of agonal breathing across various video resolutions. There was no significant difference in successful recognition between video resolutions ranging from 240p to 720p. However, the recognition rate and rate of time delay less than 10 seconds nearly doubled when the frame rate increased from 15 fps to 30 fps (Table 4), and the rate of time delay less than 10 seconds between 15-fps group and 30-fps group had statistical significance.

Table 1 – Mobile network settings (normal/occasionally reduced) and agonal recognition rate.

Scenario	Bandwidth (Mbps)	Mean delay (ms)	Jitter (ms)	Packet loss rate (%)	Recognition rate (%)
(1)	10/1	40/60	10/30	0.2/5	77.8
(2)	10/1	40/60	10/30	0.2/10	57.9
(3)	10/-	60/-	30/-	0.5/-	54.2

Mbps: megabits per second; ms: millisecond.

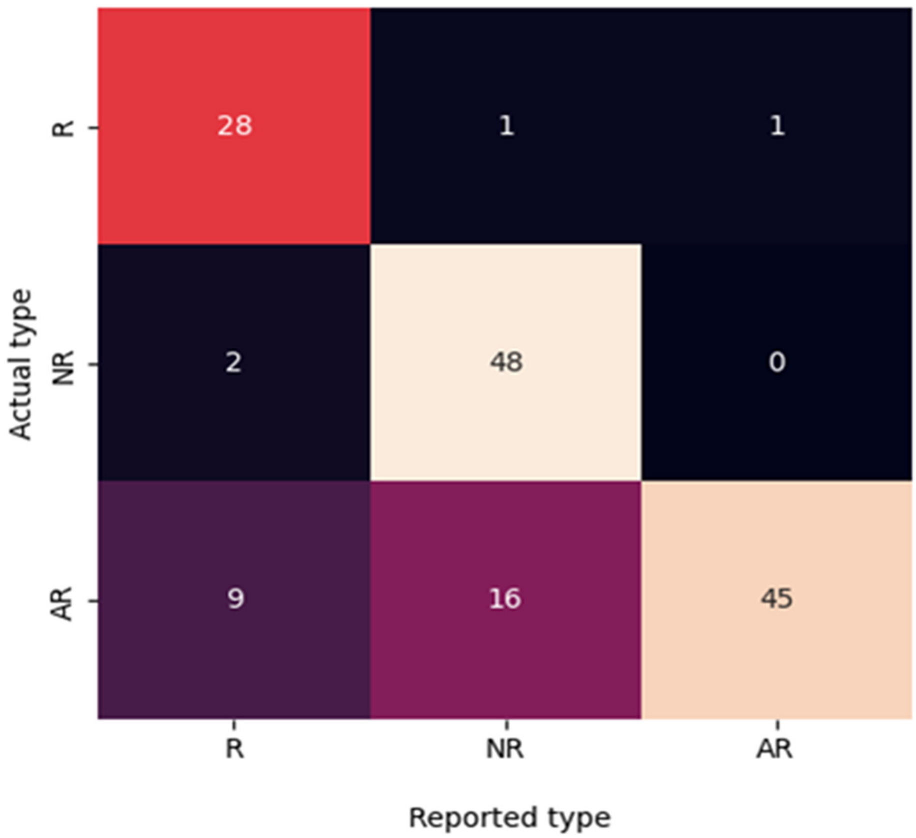

Fig. 1 – Distribution of replies and actual breathing patterns. (R: normal breathing; NR: not breathing; AR: agonal breathing).

Table 2 – Success rates and time delays for agonal breathing recognition.

Participant	Recognition rate (%)	Time delay (s)
1	78.6% (11/14)	21.3
2	78.6% (11/14)	18.2
3	21.4% (3/14)	135
4	78.6% (11/14)	16.2
5	64.3% (9/14)	8.9

Table 3 – Accuracy of agonal breathing recognition under different video resolution.

	720p	480p	360p	240p	*p*-value
Recognition rate	59% (10/17)	64% (18/28)	67% (8/12)	69% (9/13)	0.94
Time delay < 10 sec	53% (9/17)	36% (10/28)	50% (6/12)	54% (7/13)	0.59

Table 4 – Accuracy of agonal breathing recognition under different frame rate.

	30 fps	15 fps	*p*-value
Recognition rate	71% (40/56)	36% (5/14)	0.12
Time delay < 10 sec	52% (29/56)	21% (3/14)	0.041

fps: frame per second.

Discussion

Our study conducted a comparative analysis to assess the impact of video resolution and frame rate on the successful recognition rate of agonal breathing.

The overall rates of successful recognition were found to be below 80%, and there was no significant difference observed across video resolutions ranging from 240p to 720p. These results indicate that the resolution of the video may not exert a substantial influence on the accuracy of agonal breathing detection. However, a notable finding emerged when investigating the effect of frame rate on agonal breathing recognition. Specifically, a considerable improvement in recognition rates was observed when the frame rate increased from 15 fps to 30 fps. The recognition rate nearly doubled at the higher frame rate setting significantly. These findings suggest adequate frame rate is needed to develop agonal breathing recognition systems under limited network condition, as higher frame rate settings demonstrated the ability to augment detection accuracy and enable more efficient and prompt responses to agonal breathing incidents.

In the context of the study, the effectiveness of viewing live-streamed breathing patterns in an ambulance, or other application such as making video-assisted 911 calls using mobile phones heavily relies on the quality of the mobile network. Ensuring optimal data transmission in limited settings is essential, and it is also important to provide adequate training for remote support personnel. The participants in our study did not receive any training for remotely recognizing agonal breathing via video before viewing the videos, and one of them had a relatively low recognition rate. Adequate training might improve his performance. In addition, a video quality reward and adjustment system, and optimal ways to facilitate the communications with on-scene paramedics for closer monitoring or repeated physical examinations need to be further explored.

Limitation

This study had several limitations. Firstly, the number of participants and the number of videos analyzed were insufficient to support performing a robust regression analysis and the capability in abilities is magnified in situations with fewer participants. Secondly, video characteristics were limited in the current network settings, and none of the adjusted videos represented real-life scenarios. We did not know whether there was any ceiling effect of increasing the frame rate, resolution or other factors such as delay, jitter, or packet loss. However, our results identified a crucial barrier for recognizing agonal breathing, and purpose-oriented streaming via bitrate adaptation was assumed to be practical. Thirdly, this study focused on the recognition of agonal and non-breathing patterns. The participants did not view videos of other abnormal respiratory patterns such as stroke, heart failure, or respiratory failure. Therefore, further studies on abnormal respiratory pattern recognition are required for video-assisted ambulance transportation.

Conclusion

The frame rate emerges as one of critical factors in agonal respiration recognition through telemedicine, outweighing the significance of video resolution, especially under limited or fluctuating network conditions. To aid on-scene EMTs, it is imperative to develop a video streaming algorithm that preserves frame rate. This strategy will assist in delivering real-time and accurate respiration recognition. Additional research is needed to explore and identify optimal streaming strategies that enhance the effectiveness of telemedicine in supporting EMTs.

CRediT authorship contribution statement

Kai-Wei Lin: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft. **Ying-Chih Ko:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft. **Wen-Hsuan Shen:** Conceptualization, Formal analysis, Methodology, Software, Writing – review & editing. **Ying-Ju Chen:** Conceptualization, Project administration. **Sheng-Wen Hou:** Conceptualization, Project administration. **Wen-Chu Chiang:** Methodology, Writing – review & editing. **Matthew Huei-Ming Ma:** Methodology, Writing – review & editing. **Hsin-Mu Tsai:** Conceptualization, Data curation, Formal analysis, Methodology, Software, Supervision, Writing – review & editing. **Ming-Ju Hsieh:** Conceptualization, Data curation, Methodology, Supervision, Validation, Project administration, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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