ITNT - 2023

An Algorithm for Detecting Artifacts in Long-Term Video-EEG Monitoring Data

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The study was carried out at the expense of the grant of the Russian Science Foundation No. 22-69-00102, https://rscf.ru/en/project/22-69-00102.

Abstract. In this work, we propose an algorithm for detecting artifacts in long-term video-EEG monitoring data in the problem of diagnosing cerebral ischemia after subarachnoid hemorrhage. The algorithm is based on a threshold detector using the smoothed optical flow value. The optical flow is calculated from the video frames of long-term video-EEG monitoring data. We conducted a computational experiment that showed the following: (a) artifacts are detected with an accuracy acceptable for diagnosing cerebral ischemia during synchronous analysis of video data and EEG signals; (b) artifacts can be detected in real time.

- Diagnosis of vascular spasm and cerebral ischemia in the initial stage of its development is the most important step in the intensive treatment of a patient with subarachnoid hemorrhage (SAH), since there are effective therapeutic and endovascular interventions that can stop and reverse this process.
- Hyperrhythmic activity characterizes a focal impairment of the functional state of the brain, reflecting the occurrence of delayed cerebral ischemia.
- Interchannel synchronization of EEG signals is typical for hyperrhythmic activity, which is pathological and can be considered as an analog of epileptiform activity in patients with severe brain damage.
- The analysis of the ridges of the spectrograms of EEG wavelet transforms makes it possible to detect interchannel synchronization.
- Existing EEG monitoring systems provide real-time EEG recording with distortions caused by instrumental artifacts and artifacts of the patient's vital activity.
- To identify time intervals with artifacts caused by the patient's vital activity and the work of the medical staff, it is advisable to analyze video recordings synchronous with the EEG.
- However, due to artifacts, the development of automatic algorithms for the detection of delayed ischemia by EEG remains an unsolved problem.

The problem: It is necessary to develop an algorithm for detecting artifacts of the patient's life activity and artifacts caused by the activity of medical personnel.

Algorithm for Event Detection

A measure of the activity in the frame

Suppose a frame of a video sequence is described as

$$I(\mathbf{x}): R^2 \to R, \ \ \mathbf{x}=(x,y)^T.$$

We define the measure of the activity as follows:

$$J(n)=\frac{1}{WH}\sum_{x=0}^{W-1}\sum_{y=0}^{H-1}\sqrt{V_x^2(x,y,n)+V_y^2(x,y,n)}+\delta(n), \ \ n=1,...,N$$

where W, H are the ROI width and height;

$V_x(x,y,n)$ and $V_y(x,y,n)$ are the optical flow values in axial directions X and Y in the frame number n at the point (x,y) ;

$\delta(n)$ is a noise.

Technique for computing the optical flow:

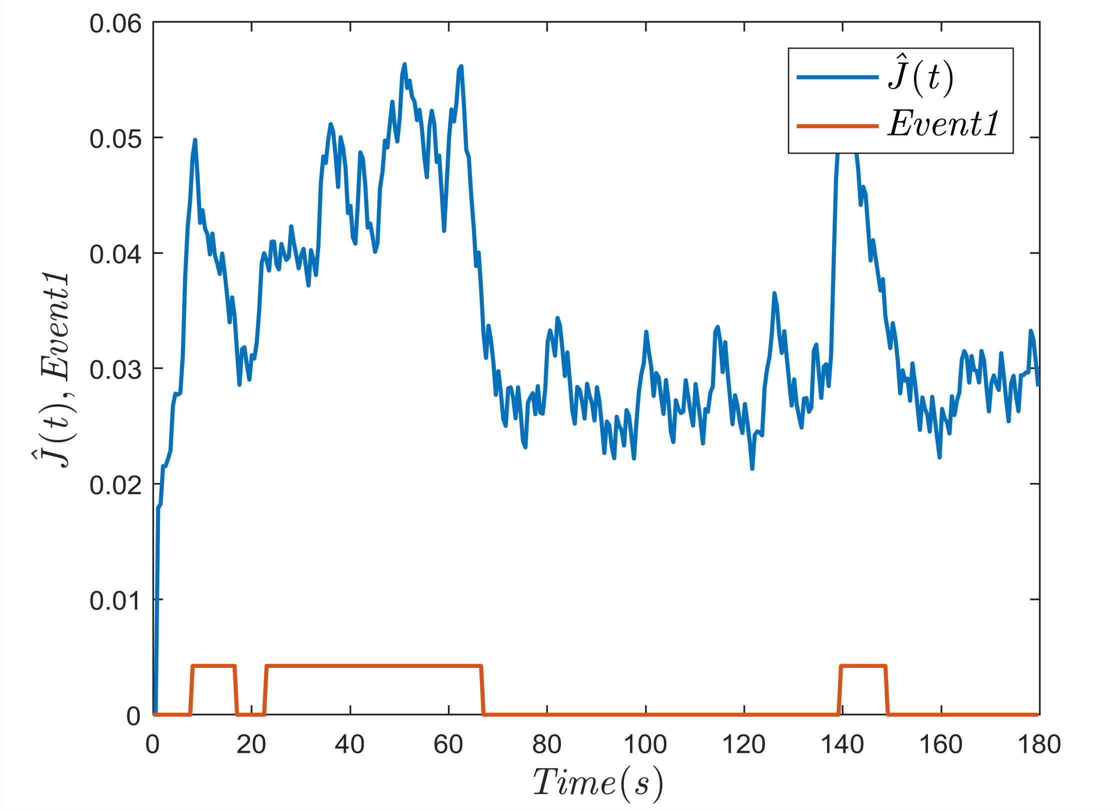
- Lucas-Kanade algorithm – involves local first-order gradient constraint.

The decision rules :

$$Event_1=\begin{cases}1, \ if \ \hat{J}(n)\geq T_1 \ and \ n-n_0\geq M; \ \ T_1=\hat{J}_0+k_1\sigma_1, \\ 0, \ if \ \hat{J}(n)<T_1 \ or \ n-n_0<M,\end{cases}$$

where T_1 is the threshold value; M is the length of the sequence of frames required to make a decision; $\hat{J}(n)$ is the Kalman estimate of $J(n)$; $\hat{J}_0(n)$ is a mean value of $\hat{J}(n)$ in a fragment of video with low dynamics of the scene; σ_1 is the standard deviation of $\hat{J}(n)$; k_1 is the coefficient.

Results of the Experiment



Graphs of the estimate $\hat{J}(t)$ and event indicator $Event_1$

An example of a region of interest

Table 1 – Results of event detection.

Fragment \Data	Events total	Predictions total	Detected correctly	Missed	False detected
VID-1-013140-D7C1	8	8	8		
VID-1-082749-17A0	2	2	2		
VID-1-164959-D7C1	18	18	18		
VID-1-190024-D7C1	3	3	3		
VID-1-193030-D7C1	11	12	11		1
VID-1-161953-D7C1	5	5	5		
VID-1-003950-9698	1	1	1		
VID-1-011935-B408	14	15	14		1
VID-1-003950-9698	6	7	6		1
VID-1-183853-B756	9	10	7	2	1
VID-1-192435-0D1F	15	15	15		
VID-1-225758-05A7	11	12	11		1
Total	103	108	101	2	5

Table 2 – Values of quality measures calculated when detecting motion artifacts.

Precision	Recall	Accuracy	F1 score
0,95	0,98	0,94	0,97

CONCLUSIONS

1. An algorithm for detecting artifacts in long-term video-EEG monitoring data in the problem of diagnosing cerebral ischemia after subarachnoid hemorrhage has been proposed.
2. We determined the values of the algorithm parameters and proposed a way to improve performance.
3. The computational experiment showed that the proposed algorithm detected 98% of artifacts in clinical videos, while the F1 score is equal to 0.97. This confirmed the possibility of reliable detection of motion artifacts in long-term video-EEG monitoring data.
4. The preliminary results showed that the proposed algorithm operates in real time.
5. In further studies, we will apply the proposed algorithm together with the algorithm for analyzing EEG signals to diagnose delayed cerebral ischemia.