An Intelligent Gradient Detector for Monitoring of Passenger Flows

Anna Gorbenko

Department of Intelligent Systems and Robotics
Ural Federal University
620083 Ekaterinburg, Russia
gorbenko.ann@gmail.com

Vladimir Popov

Department of Intelligent Systems and Robotics
Ural Federal University
620083 Ekaterinburg, Russia
Vladimir.Popov@usu.ru

Abstract

In this paper, we study the problem of monitoring of passenger flows. In particular, we consider an intelligent gradient algorithm to solve the problem.

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A large number of problems of technical vision extensively studied recently (see e.g. [1] – [4]). In particular, we can mention visual navigation in robotics (see e.g. [5] – [24]). In this paper, we study the problem of monitoring of passenger flows and consider an intelligent gradient algorithm to solve the problem. In particular, we use the following algorithm.

We consider video files that have been received from one bus camera. Our model uses an image of bus with only free chairs as the reference image Im. First of all, the reference image should be recognized. In particular, areas of interest should be defined. We consider a video file as a sequence of images

$$\mathrm{Im}_1, \ldots, \mathrm{Im}_n.$$

Different gradient methods are quite frequently used in technical vision. In particular, we can mention Sobel filter and Canny edge detector. However, the effectiveness of these methods depends essentially on the noise level. Since in bus environment we have very high level of different noises, direct application of gradient methods give us very low level of recognition.

We consider standard gradient operator:

$$\nabla f = \frac{\partial f}{\partial x}\vec{e_x} + \frac{\partial f}{\partial y}\vec{e_y}.$$

Application of ∇f to different reference images and video files allows us to obtain two sets $\mathcal{R}$ and $\mathcal{V}$ where $\mathcal{R}$ is the set of values of ∇f for pixel of reference images and $\mathcal{V}$ is the set of values of ∇f for pixel of images from video files. We use a genetic algorithm for separation of $\mathcal{R}$ and $\mathcal{V}$ by multithreshold function. We denote our algorithm by $\mathcal{CS}[0]$. Let $\mathcal{CS}[1]$ be the algorithm $\mathcal{CS}[0]$ with intelligent visual landmarks model from [25].

In our experiments, we consider a sequence of files

$$F[0], F[1], \ldots, F[11].$$

We have obtained the exact number $Num(F[i])$ of passengers for each $F[i]$ using visual observation. We consider only images $F[i,j]$, $0 \leq j \leq 9$, for each video file $F[i]$, $1 \leq i \leq 11$. For any image X and detector Y, let $R(X,Y)$ be the result of detection of passengers on the image X by the detector Y.

Let

$$N = \frac{\sum\limits_{i=0}^{11} Num(F[i])}{12}.$$

In our case, $N = 10.33$. Let

$$P[h] = \frac{\sum\limits_{i=0}^{11}\sum\limits_{j=0}^{9} R(F[i,j], H[h])}{120}.$$

where $H[h]$ is a Haar cascade, $0 \leq h \leq 5$, (see [25]). Let

$$P[h+6] = \frac{\sum\limits_{i=0}^{11}\sum\limits_{j=0}^{9} R(F[i,j], \mathcal{S}[h])}{120}$$

where $h \in \{0, 1\}$. Selected experimental results are given in Figure 1.

Note that $R(X,Y)$ includes some errors. Let $L(X,Y)$ be the number of detections of passengers where they are not exist. Let $M(X,Y)$ be the number of re-detections. Let

$$L[h] = \frac{\sum\limits_{i=0}^{11}\sum\limits_{j=0}^{9} L(F[i,j], H[h])}{120},$$

h	0	1	2	3	4	5	6	7
$P[h]$	3.91	4.2	2.98	2.01	2.33	3.81	7.86	7.97

Figure 1: Comparison of $\mathcal{CS}$ and Haar cascades.

$$M[h] = \frac{\sum\limits_{i=0}^{11} \sum\limits_{j=0}^{9} M(F[i,j], H[h])}{120},$$

where $0 \le h \le 5$. Let

$$L[h+6] = \frac{\sum\limits_{i=0}^{11} \sum\limits_{j=0}^{9} L(F[i,j], \mathcal{CS}[h])}{120},$$

$$M[h+6] = \frac{\sum\limits_{i=0}^{11} \sum\limits_{j=0}^{9} M(F[i,j], \mathcal{CS}[h])}{120},$$

where $0 \le h \le 1$. Selected experimental results are given in Figure 2.

h	0	1	2	3	4	5	6	7
$L[h]$	0.52	0.53	0.25	0.15	0.14	0.52	3.32	0.56
$M[h]$	0.56	0.2	0.13	0.05	0.05	0.37	0.2	0.28

Figure 2: Comparison of errors of $\mathcal{CS}$ and Haar cascades.

Note that usage of the intelligent visual landmarks model from [25] allows us not only re-adjust reference images, but gives us information on frequency and values of changes of sets $\mathcal{R}$ and $\mathcal{V}$. We create a genetic algorithm based on this information for re-adjustment of the multithreshold function. Selected experimental results are given in Figure 3.

average number of generations	10^3	10^4	10^5	10^6
number of detections	1.04	1.16	1.23	1.27
number of non-existent detections	0.83	0.24	0.14	0.035 %
number of re-detections	0.78	0.46	0.32	0.31

Figure 3: The dependence of the quality of recognition from the number of generations of genetic algorithm for re-adjustment of the multithreshold function where we consider 1 as value for recognition with $\mathcal{CS}[1]$.

References

[1] A. Gorbenko, A. Lutov, M. Mornev, and V. Popov, Algebras of Stepping Motor Programs, *Applied Mathematical Sciences*, 5 (2011), 1679-1692.

[2] A. Gorbenko and V. Popov, Self-Learning Algorithm for Visual Recognition and Object Categorization for Autonomous Mobile Robots, *Lecture Notes in Electrical Engineering*, 107 (2012), 1289-1295.

[3] A. Gorbenko and V. Popov, On Face Detection from Compressed Video Streams, *Applied Mathematical Sciences*, 6 (2012), 4763-4766.

[4] A. Gorbenko and V. Popov, Usage of the Laplace Transform as a Basic Algorithm of Railroad Tracks Recognition, *International Journal of Mathematical Analysis*, 6 (2012), 2413-2417.

[5] A. Gorbenko, M. Mornev, V. Popov, and A. Sheka, The problem of sensor placement for triangulation-based localisation, *International Journal of Automation and Control*, 5 (2011), 245-253.

[6] A. Gorbenko and V. Popov, On the Problem of Placement of Visual Landmarks, *Applied Mathematical Sciences*, 6 (2012), 689-696.

[7] A. Gorbenko and V. Popov, The Problem of Selection of a Minimal Set of Visual Landmarks, *Applied Mathematical Sciences*, 6 (2012), 4729-4732.

[8] A. Gorbenko and V. Popov, A Real-World Experiments Setup for Investigations of the Problem of Visual Landmarks Selection for Mobile Robots, *Applied Mathematical Sciences*, 6 (2012), 4767-4771.

[9] A. Gorbenko and V. Popov, Computational Experiments for the Problem of Selection of a Minimal Set of Visual Landmarks, *Applied Mathematical Sciences*, 6 (2012), 5775-5780.

[10] V. Popov, Partially Distinguishable Guards, *Applied Mathematical Sciences*, 6 (2012), 6587-6591.

[11] A. Gorbenko, M. Mornev, V. Popov, and A. Sheka, The Problem of Sensor Placement, *Advanced Studies in Theoretical Physics*, 6 (2012), 965-967.

[12] A. Gorbenko and V. Popov, On the Problem of Sensor Placement, *Advanced Studies in Theoretical Physics*, 6 (2012), 1117-1120.

[13] A. Gorbenko and V. Popov, Anticipation in Simple Robot Navigation and Learning of Effects of Robot's Actions and Changes of the Environment, *International Journal of Mathematical Analysis*, 6 (2012), 2747-2751.

[14] A. Gorbenko and V. Popov, SAT Solvers for the Problem of Sensor Placement, *Advanced Studies in Theoretical Physics*, 6 (2012), 1235-1238.

[15] A. Gorbenko and V. Popov, Anticipation in Simple Robot Navigation and Finding Regularities, *Applied Mathematical Sciences*, 6 (2012), 6577-6581.

[16] A. Gorbenko and V. Popov, Robot Self-Awareness: Formulation of Hypotheses Based on the Discovered Regularities, *Applied Mathematical Sciences*, 6 (2012), 6583-6585.

[17] A. Gorbenko and V. Popov, Robot Self-Awareness: Usage of Co-training for Distance Functions for Sequences of Images, *Advanced Studies in Theoretical Physics*, 6 (2012), 1243-1246.

[18] A. Gorbenko and V. Popov, Robot's Actions and Automatic Generation of Distance Functions for Sequences of Images, *Advanced Studies in Theoretical Physics*, 6 (2012), 1247-1251.

[19] A. Gorbenko, V. Popov, and A. Sheka, Localization on Discrete Grid Graphs, *Lecture Notes in Electrical Engineering*, 107 (2012), 971-978.

[20] A. Gorbenko and V. Popov, The c-Fragment Longest Arc-Preserving Common Subsequence Problem, *IAENG International Journal of Computer Science*, 39 (2012), 231-238.

[21] A. Gorbenko and V. Popov, Robot Self-Awareness: Occam's Razor for Fluents, *International Journal of Mathematical Analysis*, 6 (2012), 1453-1455.

[22] A. Gorbenko and V. Popov, The Force Law Design of Artificial Physics Optimization for Robot Anticipation of Motion, *Advanced Studies in Theoretical Physics*, 6 (2012), 625-628.

[23] A. Gorbenko, V. Popov, and A. Sheka, Robot Self-Awareness: Exploration of Internal States, *Applied Mathematical Sciences*, 6 (2012), 675-688.

[24] A. Gorbenko, V. Popov, and A. Sheka, Robot Self-Awareness: Temporal Relation Based Data Mining, *Engineering Letters*, 19 (2011), 169-178.

[25] A. Gorbenko and V. Popov, Face Detection and Visual Landmarks Approach to Monitoring of the Environment, *International Journal of Mathematical Analysis*, 7 (2013), 213-217.