Saliency Detection For Maritime Search And Rescue Using SVD To The Amplitude Spectrum

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Background of maritime search and rescue based on computer vision

Ship distress accidents increased with the higher density of ships

It is reported during past 2011 more than 100 persons were lost or dead in the shipwreck and direct economic losses are billions of yuan (Wang, 2012)

To Improve the success rate of maritime search and rescue is important
Background of maritime search and rescue based on computer vision

Computer vision
Sensors
Communication
...

Improve the ability of maritime search and rescue

Shanghai Maritime University and Donghai Rescue Bureau Ministry of Communications finished the project of Technology research about machine vision system for maritime search and rescue, and also involved the work of Demonstration and application of maritime emergency search and rescue command system
The maritime search and rescue tasks are depended on human eyes which would be tired.

To solve the problem, vision enhancement system for maritime search and rescue (SAR-VES) was developed.

The system provides novel technology and equipment for maritime search and rescue and helps to search targets.
Background of maritime search and rescue based on computer vision

Visible light subsystem

Infrared subsystem

Radar subsystem

The control subsystem
Introduction of detection methods based on visible light images for maritime search and rescue

• Target color based (common orange) detection method (Sumimoto et.al, 1994)
• Image filtering and statistical method for detection rafts (Yamamoto et.al, 1999)
• Person location based on machine vision technology (Westall et.al, 2007)
• Maritime search and rescue robot using omnidirectional camera (Rong et.al, 2007)
Visual attention is an important psychological mechanism of human when processing visual information, which can allocate finite resource of information processing and makes human hold the selective ability. Its goal is to rapidly direct human attention to interest targets.

The main problem of computational visual attention model is saliency detection, that is to detect the salient region of image or video.
The applications of saliency detection include,
• robot location and navigation,
• image retrieval,
• image retargeting,
• target detection and tracking in cluttered scenes,
• face recognition,
• images segmentation,
• image quality assessment,
• image and video compression…

The saliency detection methods are classified into two categories (from the domain of process),
• Space domain
• Frequency domain
The main saliency detection methods from frequency domain

- Spectrum residual (SR, Hou et.al, 2007)
- Quaternion Fourier transform (QPFT, Guo et.al, 2008)
- Pulse Discrete Cosine transform (PDCT, Yu et.al, 2009)
- Image signature (IS, Hou et.al, 2012)
- Bi Quaternion Fourier transform (BQFT, Ding et.al, 2012)
- Amplitude patching (Fang et.al, 2012)

...
Proposed method:
• The amplitude spectrum of image represents the proportions of distinct frequency components. Singular value decomposition can extract the main component of image.
• For image of maritime search and rescue, small targets often occupy the high frequency bands which are non-dominant components.
• Therefore, most background and sea clutters have be removed in the inverse Fourier transform of non-dominant part of amplitude spectrum with original phase spectrum.
Saliency detection of maritime search and rescue from frequency domain

**SVD:**

The singular value decomposition of matrix $A \in \mathbb{R}^{m \times n}$ is

$$A = U \Sigma V^T$$

where $U \in \mathbb{R}^{m \times m}$ and $V \in \mathbb{R}^{n \times n}$ are unitary matrices,

$$\Sigma = \begin{bmatrix}
\Sigma_1 & 0 \\
0 & 0
\end{bmatrix}$$

is a diagonal matrix with nonnegative real numbers on the diagonal

$$\Sigma_1 = \text{diag}(\sigma_1, \sigma_2, \cdots, \sigma_r)$$

$$\sigma_1 \geq \sigma_2 \geq \cdots \geq \sigma_r > 0, \quad r = \text{rank}(A)$$
Saliency detection of maritime search and rescue from frequency domain

**Saliency computation:**
To extract the main component of amplitude spectrum, we select certain threshold \( th \) to satisfy,

\[
\sum_{i=1}^{p} \sigma_i / \sum_{i=1}^{r} \sigma_i \geq th
\]  
(4)

where \( p \) is the minimum to match (4). Then the saliency map of image can be obtained by,

\[
S = \left\| IF \left[ \exp \left( \log A_s + j\phi \right) \right] \right\|^2
\]

where IF is denoted as the inverse Fourier transform, and \( A_s \) represents the amplitude spectrum of non-dominant components computed by,

\[
A_s = \left| A - U_p \Sigma_p V_p^T \right|
\]
Saliency detection of maritime search and rescue from frequency domain

Flow chat of proposed method

- Image of SAR
  - Red
    - FT
  - Green
    - FT
  - Blue
    - FT
  - Yellow
    - FT
  - Intensity
    - FT
  - SVD of amplitude spectrum
    - Saliency computation
      - Color saliency map
      - Intensity saliency map
      - Master saliency map
Experiments and analysis

- **Experiment platform**: Matlab2009(a)
- **Results of experiment**
Experiments and analysis

Analysis of result

• Because most targets for maritime search and rescue are small which occupy the high frequency bands and the low frequency components are dominant, salient region and non salient regions can be separated by SVD using certain threshold.
• The proposed method is also based on the spectrum whitening of image.

The advantages over other saliency detection methods

• The proposed method uses the original size image and down-sampling is not needed. As a result, no information about visual scene is lost and is helpful to small target detection.
• Fusion of multi-scale images is not needed.
Conclusion

• A novel saliency detection method based on visible light images is presented for maritime search and rescue. SVD is applied to amplitude spectrum of image to extract the main components and the novel information is obtained by the inverse Fourier transform of difference of original amplitude and the main components.

• The small target of visual scene for maritime search and rescue can be detected.

• The proposed saliency detection method is the basis of salient object detection for maritime search and rescue.

Future work

• Further research about adaptive selection of threshold is needed.
Thank you!