Visible and Infrared Composite Detection Sensor Information Fusion Method on Target Detection and Distinguish

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Abstract
Multi-sensor data fusion technology can effectively improve the reliability and stability of the sensor test system, Multi-sensor information fusion can improve the identification of target information in complex environment. In this paper, fuzzy composite sensor data fusion recognition algorithm, the sensor data fusion processing model and processing algorithm of the visible and infrared bands are established, gives the target information and decision logic output, calculates the multi-sensor data fusion recognition result by experimental data, the results show that the target information with high support is close to the real target information, the fuzzy sensor data fusion method is effective to avoid the limitation of single sensor, the proposed method can realize the consistency recognition of fuzzy sensor on the basis of fully considering the importance of each sensor and the similarity of output result.

Key words: Data Fusion, Composite perception, Target information, Decision logic

1. INTRODUCTION
Multi-sensor data fusion technology can effectively improve the reliability and stability of the sensor test system, in the industrial and military areas have been very good application and development. In particularly, multi-sensor data fusion can effectively eliminate and identify false data, improves the complex environment of the target information recognition efficiency in the complex environment (Chen and Tu, 2014; Guo and Wang, 2004). According to the different application environment, a wide variety of sensor technology types can be adapted to different production and application occasions, and effectively promote the development of sensor technology at home and abroad, however, with the complexity of the environment increases, the sensors also exist fuzzy discrimination for intelligent perception of the environment, in order to solve the fuzzy data information diagnosis, gives a variety of sensor data fusion identification methods for different environment, the composite photoelectric detection sensor under the complex environment, as the photoelectric sensor using different band imaging detection mechanism, the information association between infrared and visible light sensor with particularity and similarity, in the light of further improving the probability of multi-composite sensor detection and recognition in complex environment, it is necessary to discuss and research the algorithm of multi-composite sensor target information fusion, and provide a more reliable theoretical basis for next generation intelligent sensor technology(Hall and Llinas, 1997; Li, Lu and Cai, 2003).

2. FUZZY COMPOSITE SENSOR DATA FUSION RECOGNITION ALGORITHM
2.1. Composite sensor target information fusion recognition construction
The multi-sensor uses the visible and infrared sensors as the core to detect the mechanism, through the visible light detector and infrared detectors to detect the target information of the comprehensive analysis, to find the most realistic target information. The working mechanism of the composite sensor is shown in Figure 1.

It can be seen from Figure 1, through the visible light band detector to detect the target information and infrared band detectors target information as a prerequisite, according to the visible and infrared wavelengths of the target information to enlarge the processing, and then based on the two target-aware information characteristics, takes fuzzy sensor data fusion measures, gives the target recognition diagnosis, gets the decision to determine.

Taking the photoelectric detection and receiving sensor of each imaging unit of the composite sensor as the core, each unit detects the target output signal as the unit proposition, and constructs the evidence of D-S data reasoning(Li, 2016; Li and Chen, 2017; Li and Sang, 2017), constructs the basic probabilistic distribution function by using the two elements of the composite sensor to detect the propositional reasoning evidence of the output signal, assigns a degree of confidence to all propositions of a composite sensor system, as an evidence body by using the basic probability distribution function of unit information of each bands detection and the
corresponding authentication frame, uses Dempster’s merger rule under the same authentication framework, combines a new evidence body into the two units of the composite sensor, makes decisions through decision rules (Lin and Jiu, 2014).

![Composite sensor working mechanism](image)

**Figure 1.** Composite sensor working mechanism

Assuming that \( b_1 \) and \( b_2 \) are the two detection unit reliability functions on the same recognition frame, \( m_1 \) and \( m_2 \) are the corresponding basic confidence distributions, \( m(A) \) is the basic confidence allocation value of \( A \). If \( b_1 \oplus \land \oplus b_2 \) exists and the basic confidence is assigned to \( m \), then \( \forall A \subset \Theta, A \neq \Phi \) can be expressed by the formula (1).

\[
m(A) = \sum_{A_1 \land A_2 \neq \Phi} m_1(A_1) \land m_2(A_2) \bigg|^{-1} \sum_{A_1 \land A_2 \neq \Phi} m_1(A_1) \land m_2(A_2) \tag{1}
\]

\( m(A) \) is the composite sensor of the two units detected the proposition merged into an overall basic credibility. As shown in Figure 2, \( m_1(A) \) and \( m_2(A) \) are the two groups of the composite sensor to detect the basic confidence distribution of the proposition \( A_j \), \( j \) is the number of targets to be detected, \( m(A_j) \) is the composite sensor of the two detection unit proposition obtained by Dempster merger to obtain the basic reliability of the distribution, by judging whether the proposition is established or not, such as the credibility and likelihood of the two detection unit propositions of the composite sensor, obtains the current target detection decision result, according to the decision result to determine the unit system after the target recognition processing close to the degree, determines the authenticity of the detection target signal(Wan,2011;Wen,2001), Figure 2 shows fusion identification processing ideas for composite sensor two detection unit target information.

![Fusion identification processing ideas for composite sensor two detection unit target information](image)

**Figure 2.** Fusion identification processing ideas for composite sensor two detection unit target information

### 2.2. Sensor data fusion target recognition algorithm

In order to obtain the decision information to determine the output of the target information(Zhang, Lu and Chen,2008;Zhang and Lei,2017), establishes the fuzzy sensor data fusion processing model and processing algorithm. In the composite detection sensor two bands of detectors for \( S_1 \) and \( S_2 \), supposing that \( m_1(A) \) is the fuzzy proposition support degree of the target signal of the visible light band, \( m_1(A) \) is the degree of fuzzy proposition support of the infrared band target signal, \( m_2(A_1) \) and \( m_2(A_k) \) respectively represent the fuzzy proposition support for the \( k \)-th target, \( S_{12} \) shows the similarity of the two detection signals of the composite detection sensor, and it can be obtained by (2).
\[ S_{12} = \frac{\min[m_i(A_i), m_2(A_i)]]}{\max[m_i(A_i), m_2(A_i)]]} \]  (2)

If the two detection target signals of the composite detection sensor are the same for fuzzy support, \( S_{12} \) is 1, if \( S_{12} \) is 0, indicating that the two bands of the detection target signal completely do not support each other, for the composite detection sensor to detect multi-target signals, we can construct a uniformity function 2 \( \times \) 2 matrix, it is shown in (3).

\[ M = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \]  (3)

The matrix (3) gives the degree of mutual support between the two detection signals of the composite detection sensor, \( G(S) \) is defined their average consistency by (4).

\[ G(S) = \frac{1}{n-1} \sum_{i=1}^{n} S_i \]  (4)

In equation (6), \( n \) is the number of units to repeat the detection, \( G(S) \) reflects the unit to detect the consistency of the target signal. In order to more correctly describe the consistency of the composite probe sensor target signal, the assignment of the output signal weights under the two bands is also considered. In general, it is empirically selected that the two unit detection outputs are considered to be the most important data and their weights are assigned to 1, and the other unit detection target signal weights are set at \([0,1]\), use \( e_i \) to denote the \( i \)-th unit detection weight, \( i = 1,2 \). After normalizing them, we can get the relative weight of the unit to detect as shown by (5).

\[ E_i = e_i / \sum_{i=1}^{n} e_i \]  (5)

In the light of truly reflecting the same target for each band unit detection signal is credible or consistent, if the consistency is significant, the band unit detects the output signal as the real target, and construct a function can be obtained by equation(6).

\[ Y = x_0 e_i + x_1 e_i G(S_i) + x_2 R_i \]  (6)

In equation (6), \( R_i \) is the degree of consistency (\( i = 1,2 \)), \( x_0, x_1, x_2 \) are the constant between 0 and 1 for two units of wavelengths(Li and Pan, 2017), we can select different values as needed in practice. If only considers the weight without considering the support between them, makes \( x_i \) is 1, if we think that each unit detects the output signal has the same weight, lets \( x_i \) is 0.

3. APPLICATION AND ANALYSIS

The target signal of the two-band detector output of the composite detection sensor is identified by the fuzzy sensor data fusion algorithm. In order to determine the target signal using two parameters that the unit to detect the output signal amplitude and signal pulse width. Assuming that the two targets are A and B, uses the membership function of D-S data reasoning, the two target parameters and measured values of the composite detection sensors are shown in Table 1.

<table>
<thead>
<tr>
<th>Detector</th>
<th>TargetA</th>
<th>TargetB</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( E_1 )</td>
<td>( \sigma_1 )</td>
<td>( E_2 )</td>
</tr>
<tr>
<td>S1</td>
<td>5.71</td>
<td>3.62</td>
<td>5.32</td>
</tr>
<tr>
<td>S2</td>
<td>7.94</td>
<td>2.23</td>
<td>5.11</td>
</tr>
</tbody>
</table>

In Table 1, \( E_i \) and \( \sigma_i \) is the mean value of the signal amplitude and standard deviation for the target A, and the amplitude of the signal amplitude and standard deviation of the target A is \( E_i \) and \( \sigma_i \).
mean value of the signal amplitude and standard deviation for the target B, and the amplitude of the signal amplitude and standard deviation of the target B is \( E \) and \( \sigma \).

\[
f(x) = 1 - \frac{(x - E)}{2\sigma}, \quad x - \mu < 2\delta
\]  

In formula (7), if \( x - E \geq 2\sigma \), thus \( f(x) \) is 0, \( x \) is the measured value of target signal, \( \{x, E\} \) represent the mean and the deviation respectively in Table 1.

The support value of the two sets target output information of the composite detection sensor to the fuzzy proposition of the system is shown in Table 2.

**Table 2.** System fuzzy proposition support

<table>
<thead>
<tr>
<th>Detector</th>
<th>Target A Joint Support</th>
<th>Joint Support for Target A</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.488</td>
<td>0.165</td>
</tr>
<tr>
<td>S2</td>
<td>0.547</td>
<td>0.641</td>
</tr>
</tbody>
</table>

According to equations (4) and (5), the corresponding average uniformity and relative consistency of the target A are shown in Table 3.

**Table 3.** The corresponding average uniformity and relative consistency of the target A

<table>
<thead>
<tr>
<th>Detector</th>
<th>Target A Average Consistency ( G(S) )</th>
<th>Target A relative consistency ( G'(S) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.667</td>
<td>0.1421</td>
</tr>
<tr>
<td>S2</td>
<td>0.604</td>
<td>0.1282</td>
</tr>
</tbody>
</table>

Assuming that the visible wavelength band detection \( S_1 \) in the composite detection sensor is the most important and the weight is 0.9, the weight of the infrared band detection \( S_2 \) is 0.1, and the relative weight uniformity of each fuzzy band detector can be obtained by using the relative weight calculation function is shown in Table 4.

**Table 4.** Calculation results of target a relative weight consistency \( R_i \)

<table>
<thead>
<tr>
<th>Detector</th>
<th>Target A Relative Weight Consistency ( R_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.1332</td>
</tr>
<tr>
<td>S2</td>
<td>0.1315</td>
</tr>
</tbody>
</table>

Assuming that the relative degree of support of the two bands of the composite detection sensor is considered to be more important than the relative weight, and let \( x_1 = 0.5, x_2 = 0.4, x_3 = 0.1 \), the consistency coefficient of the output information of each band unit of the composite detection sensor is shown in Table 5.

According to the Table 5, it can be calculated that the support of the detection is 0.213 under the two bands of the composite detection sensor for the proposition "signal is target A"; similarly, it can be calculated that the support of the detection is 0.213 under the two bands of the composite detection sensor for the proposition "signal is target B".

It can be obtained from the calculation results that the support for target A is greater than that on target B, it can be considered that target A is actual target information by composite detection sensor detection.

**Table 5.** Calculation results of target a relative weight consistency

<table>
<thead>
<tr>
<th>Detector</th>
<th>Target A Relative Weight Consistency ( R_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.1824</td>
</tr>
<tr>
<td>S2</td>
<td>0.1511</td>
</tr>
</tbody>
</table>

4. CONCLUSIONS

In this paper, the D-S data fusion recognition method is used to establish the fusion algorithm of visible light band and infrared band sensor data, obtains the corresponding calculation function, calculates the result of fusion recognition by the experimental data, the results show that the target information with high support close to the real target information, through the decision theorem can determine the authenticity of the target information. The fuzzy sensor data fusion method is effective to avoid the limitation of single sensor, joints identification of the two measured values of multiple band detection sensors to reduce the influence of the sensor uncertainty error and the error judgment, proposes method can realize the consistency recognition of fuzzy sensor on the basis of fully considering the importance of each sensor and the similarity of output result, corresponds with the real information of multi-sensor recognition in various situations.
REFERENCES