Implementation and Comparison of Detection Algorithm for Non Intrusive Load Switching Events

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Abstract. For the intelligent development of electric power, NILM appears to save a lot of manpower and material resources compared to the traditional charge detection. NILM only need to install monitoring equipment in power at the entrance, by monitoring the voltage and current signals, we can analyze the type and operation of a single load in the cluster, so as to realize the scientific and reasonable management of electric power. With the development of NILM technology, a variety of detection algorithm for NILM has also been widespread concern and development. In this paper, based on the STM32 embedded development board to build a set of NILM system. On the basis of the software, an event detection algorithm based on current and power based on switching event is realized. According to the two kinds of algorithms, the experiment results are compared with the actual test results, and finally come to the conclusion: if the test equipment is a pure resistive electrical equipment, the accuracy rate is almost 100\%, while for the non-pure resistive electrical appliances, the accuracy of the test is different because of the different electrical.

Introduction

Energy demand is an important foundation for human survival and development of social progress. With the development of science and technology, more and more people pay attention to the sustainable development of energy. In daily life, electric energy is the most commonly used energy consumption, how to effectively use the power, as far as possible to save unnecessary waste, has become increasingly concerned about the topic [1]. Smart grid is the goal of the future power grid [2], and its implementation needs to rely on the implementation of NILM technology. NILM is a process to analysis the changes of voltage and current into a building and infer what is the use of equipment in buildings and the energy consumption. It is a typical application of single point detection technology. It can potentially enable energy solutions, manage the use of energy and reduce waste, detect and determine the energy waste of the equipment to improve energy efficiency [3-11]. The realization of NILM needs three steps: switching event detection, feature extraction and feature matching, and the detection of electrical switching events is the most basic and crucial step.

Electrical switch event detection algorithm based on current. When the electrical circuit is not running, the current will maintain a fluctuating value, when new appliances open run at the moment, the current in the circuit value can have...
instantaneous change accordingly, after the electric appliances run smoothly after current will be stable in a relatively fluctuating value. When close event occurs, the current value of the circuit will also be in the electrical stable operation of the instantaneous changes based on the occurrence of current. By detecting the instantaneous value of the opening and closing, the opening and closing of the electric appliance is judged.

Electrical switch event detection algorithm based on power. The principle of current based switching event detection is the same, when an electrical circuit in the open and closed circuit in power, there will be great changes in this moment, through the detection of the change of value to determine the opening and closing of electrical appliances.

**Electrical Switch Detection Algorithm**

**Electrical Switch Event Detection Algorithm Based on Current**

According to the formula 1 to calculate the strength of the current ($I_{\text{int \ intensity}}$), mean ($I$) in the formula represents the current average of the current cycle, and $N$ indicates that the current stored in this cycle is worth a few [12]. The online detection of electrical switches, current intensity values will occur relatively large changes in the instantaneous, according to the formula 2 to calculate the current strength of the adjacent cycle, which $S$ represents the $S$ cycle. When the current intensity difference is greater than a certain value, the electric appliance can be judged to be open or closed.

$$I_{\text{int \ intensity}} = \frac{\sum_{j=1}^{N} [i(j) - \text{mean} (i)]}{N}$$

(1)

$$\Delta I_{\text{intensity}} = (I_{\text{intensity}})_{S+1} - (I_{\text{intensity}})_{S}$$

(2)

The implementation is to use 74 data points as a processing cycle, which derived from actual test. So the $N$ is 74 in the formula 1. Then calculate the current average value of each cycle-mean ($i$). Calculate the current intensity according to the formula 1. Here to test two kinds of electrical appliances: kettle and desktop computers (The kettle model is Midea MK-H517E2 and The desktop computers model is Haier LX3-D046). Because of these two kinds of electric current and power difference and the change of current and power in the switch of the desktop computer is more complicated, so choose these two electric appliances to compare. Changes in the intensity of current intensity of kettle switches is shown in Figure 1 and the changes of desktop computer is shown in Figure 2.
Then according to the formula 2, calculated the difference of current intensity during the week. Changes in current intensity difference of kettle is shown in Figure 3 and the changed of Desktop Computer is shown if Figure 4. According to these Figures, we can clear find that there was an obvious change in the opening and closing moments. The kettle is opened and closed 5 times, the desktop is turned on and off for 1 times. According to these changes, we can determine the threshold value $\alpha$, so as to accurately judge the switch.
Electrical Switch Event Detection Algorithm Based on Power

Based on the calculation method of the current intensity, we realize the event detection algorithm based on power switch. The implementation of electrical switch event detection algorithm based on power firstly need to calculate $P'$ according to formula 3. Then calculate the power difference $\Delta P$ according to the formula 4.

\[
P' = \frac{\sum_{j=1}^{N} | p(j) - \text{mean}(i) |}{N}
\]  

(1)

\[
\Delta P = (P')_i + 1 - (P')_i
\]  

(2)

Similarly, we select the kettle and desktop as our object of detection. Change of $P'$ in kettle switching event is shown in Figure 5 and the Figure 6 is about Desktop Computer.
According to formula 4, the calculation of the power difference between the kettle and the desktop computer is shown in Figure 7 and figure 8.
Figure 7 and figure 8 can be seen, we have done 6 times the kettle opening and closing experiment, 1 times of the opening and closing the desktop. From the experimental results, it can be found that the detection of the desktop, based on the power of the detection algorithm, the data waveform is much more obvious than the detection algorithm based on current, thus the choice of threshold and the judgment are more accurate.

Comparison

Using current and electric power switch detection method based on the commonly used electrical detection was carried out following family switching events, each kind of electrical appliances do 50 sets of tests, the final two algorithms of electrical switch event detection accuracy of the results is shown in table 1.

<table>
<thead>
<tr>
<th>Load Name</th>
<th>Electrical switch event detection algorithm based on current</th>
<th>Electrical switch event detection algorithm based on power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open Event</td>
<td>Close Event</td>
</tr>
<tr>
<td>Kettle</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Electric Fan</td>
<td>98%</td>
<td>96%</td>
</tr>
<tr>
<td>Electric Light</td>
<td>98%</td>
<td>98%</td>
</tr>
<tr>
<td>Electric Heating</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>98%</td>
<td>96%</td>
</tr>
<tr>
<td>Desktop Computer</td>
<td>98%</td>
<td>96%</td>
</tr>
<tr>
<td>Air Conditioner</td>
<td>80%</td>
<td>78%</td>
</tr>
<tr>
<td>Microwave Oven (low fire)</td>
<td>84%</td>
<td>84%</td>
</tr>
</tbody>
</table>

Table 1. Comparison results on the accuracy of detection.

Summary

This paper completes the NILM system based on the STM32 embedded development board, and the software realization of switch current detection and event detection algorithm based on event power switch. Through a large number of scientific experiments and data comparison, two kinds of event detection algorithm in the actual electrical switch detection accuracy of a scientific comparison. Finally come to the
conclusion: if the test equipment is a pure resistive electrical equipment, the accuracy rate is almost 100%, while for the non-pure resistive electrical appliances, the accuracy of the two detection algorithms all decreased significantly and it is different because of the different electrical. It needs to be pointed out that if the threshold for a particular set of electrical equipment, then the accuracy of the detection of the electrical equipment will be significantly improved. So achieve adaptive threshold for different electrical appliances is an important way to improve the accuracy of detection.

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References