Investigation of tipping bucket rain gauges using digital photographic technology

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When studying the tipping bucket rain gauge (TBR), it is rather difficult to make an objective and sophisticated measurement of the duration of bucket rotation. From the perspective of digital photographic technology, however, the problem can be easily solved. The primary interest of this research has been to use digital photographic technology to study the TBR under laboratory conditions. In this study, the interframe difference algorithm and a camera recording device were used. Based on three types of JDZ TBRs, the time variation characteristics of bucket rotation were obtained. The time from the beginning of a tip to the time that the bucket is horizontal ($T_1$) and the time for a complete tip ($T_2$) were analyzed in detail. The results showed that $T_1$ and $T_2$ were functions of rainfall intensity, and $T_1$, $T_2$ decrease as the rain intensity increases significantly ($P<0.001$). Moreover, excellent evidence shows that the averages of $T_1$ and $T_2$ were positively correlated with bucket mass. It took more time for the bucket to tip as the mass of the bucket increased. Furthermore, the error of each TBR was calculated by the new proposed error calculation formula, and the new method was compared with the traditional method. The results from the two methods were very close, which demonstrates the correctness and feasibility of the new formula. However, the traditional calibration cannot acquire the variation characteristics of the tipping time, but the proposed approach can achieve this.