

## Hydrometer Test Automation Using Time of Flight Distance and Digital Temperature Sensor

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Soil particle size influences various physical, chemical and biological properties of soil. Hydrometer test is the most commonly used method for soil particle analysis because of its inexpensive instrumental setup and simple use. Soil models and pedotransfer functions often require inputs of different particle diameter which is tedious to obtain using traditional Hydrometer method. Also, there is a high possibility of the occurrence of human errors as it involves measuring hydrometer reading at different particle setting time. The objective of this study was to develop an automated and simple method for evaluating a complete soil particle-size distribution.

In this study, Adafruit VL6180X Time of Flight Distance (ToF) Ranging Sensor was used to measure the distance between the sensor and the tip of the hydrometer. An initial distance between the sensor and tip of the hydrometer was recorded and used to convert the distance to the hydrometer reading. The temperature of the solution was measured at the same time using the waterproof DS18B20 1-Wire digital temperature sensor. Arduino Uno R3 was used to program the ToF sensor to record both the distance and the temperature at 5 seconds interval. The recording of the distance with time was converted to particle diameter and concentration based on Stoke's law. The whole particle-size distribution, from  $50 \mu\text{m}$  to  $2 \mu\text{m}$ , can be obtained within 8 hours.

A total of 8 types of soil samples with different soil texture was used to test the system. As a comparison, the measurement from the automated system was checked against the standard pipette method. Results show that measurement of the percentages finer than  $2, 5, 10, 20$  and  $50 \mu\text{m}$  obtained by the two methods are highly correlated, with  $R^2$  values between 0.85 to 0.99. The whole system costs less than \$70 (USD) and provides an easy, efficient and cost-effective way for soil particle size distribution.