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Friction coefficient determination by electrical resistance measurements

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We designed and present in the following an alternative method for measuring the coefficient of friction between two surfaces, using a conductive rubber cord as a force sensor, with it's electrical resistance being dependent on the force and tension in the rubber cord. The advantage of the method is that it is cheap, fiable and easy to realize, properties which are provided by the Arduino programmable interface and board and thanks to this it also provides high quantities of data.
The research project had several steps and components: the calibration of the electrical conductor rubber cord force sensor; writing the code for driving the stepper motor and for reading data from the sensors; realizing the experiment itself and acquiring the experimental data; respectively the analysis and interpretation of the experimental data, drawing the conclusions of the project, and also identifying the possibilities of enhancing and further developing this research. Our work is indented, first of all, to High School and/or University level laboratory projects, but the perspectives of further developing the experiments and our system encourages us to think and work on the implementation possibilities for studying more advanced systems, such as complex dynamic systems, modeling of various phenomena and other similar experimental setups in the near future.

Summary

Over the past few years, several experimental papers have been published published on the general topic of dry friction.

In this talk, I will present an original Arduino-driven experiment for the study of friction and the measurement of the friction coefficient between wood and various surfaces, using a conductive FSR (Force Sensing Resistance) rubber cord as force sensor.
The conductive rubber cord is a polymer containing carbon, and as its name suggests, has two unique properties: (1) it conducts electric current, (2) the electrical resistance exhibited is much smaller than that of its classical, insulating counterpart and it changes when stretched. If proper contacts are attached, such a cord can be used in a resistive voltage divider connection as an FSR.

During the experiments, a rectangular wood block (dimensions: 3.2cm × 4.8cm × 6.8cm, weight: 99.944g) was pulled at a constant speed on a wood board, a glass sheet, or a sheet of common printer/copy paper, with the conductive rubber cord, via a 28BYJ-48 type unipolar stepper motor, driven via a ULN2003 driver and controlled by the Arduino UNO platform. The same platform was used to constantly monitor and record the electrical resistance of the rubber cord by the means of the voltage divider technique. The Arduino programming code that was needed to measure the resistance of the rubber cord, to collect the experimental data, and to drive and control the stepper motor will be also briefly presented at the conference.

As expected, in the case of the wood on wood or paper, a stick-and-slip behaviour was observed. For wood on glass sliding was demonstrable too. In each case, frictional forces were determined from the electrical resistance variation of the rubber cord corresponding to the magnitude of the measured force, as defined by the initial calibration.
All experiments were repeated to determine the friction coefficient via a spring balance type dynamometer, too. In this latter case, in order to ensure constant and continuous pulling, the dynamometer was pulled via a stepper motor. The comparative results for the friction coefficients will be presented in form of a table and corresponding discussion.
The friction coefficients obtained using the force-sensitive conductive-rubber resistor are in good agreement with those obtained by the dynamometer or presented in the existing literature.

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