Digital Inclinometer

Abstract:

Range of motion measurement using wearable sensors is an inexpensive, convenient, and efficient manner of providing useful information for joint disorder. Classical digital inclinometers can only measure joint angles in a vertical plane. This paper describes an embedded system that measures joint angles simultaneously in vertical and horizontal planes. It is based on gravitational acceleration and magnetic field sensors measurements. The method used in order to measure the correct angles for a given position of the device is described. A Graphical User Interface has been developed to display simultaneously the flexion-extension, abduction-adduction and internal-external rotations of the upper limb joint angles during a movement performed by a subject. This movement is reconstructed in a 3D real-time animation.

Introduction:

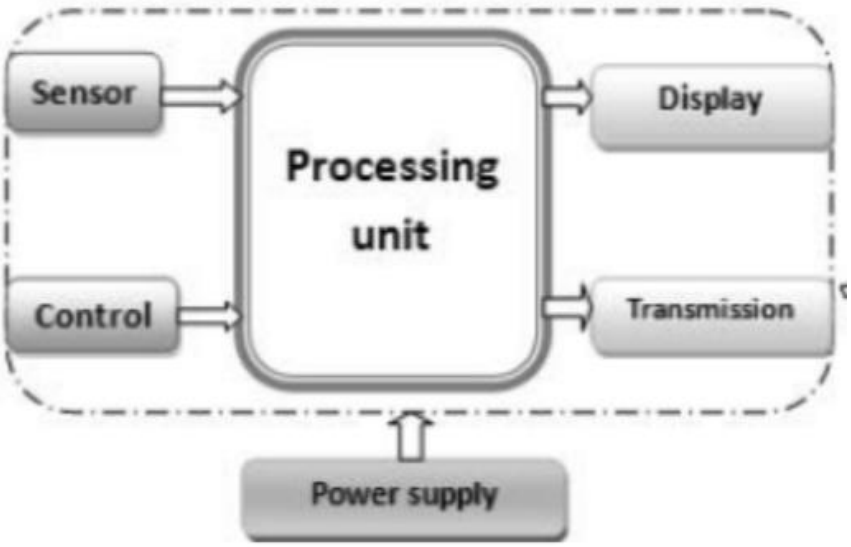
An inclinometer or clinometer is an instrument for measuring tilt angle of an object with respect to horizon or gravity. It can be used in very different applications such as geotechnical instrumentation on transportation projects, civil engineering or planet rover localization when combined with a sun sensor. These sensors have also been utilized for measuring cruising yacht freeboards as well as in robotics and medical applications. Joint angular sensors are widely used in the

industry, from highly effective robots in product lines and heavy construction machines in building sites to small knobs on home appliances as well as in rehabilitation or physical therapy. In medical or clinical applications, the inclinometer determines a person's range of motion. Typically, range of motion ROM is referenced from the body's natural position. If a patient experiences decreased range of motion in a joint, the therapist can use several kinds of goniometers to assess the range of motion. For example, examination of shoulder mobility may be accomplished using visual observation or instruments such as goniometers, electro-goniometers and digital inclinometers.

Based on the method proposed above, Goniometry has been used widely due to its portability and low cost. However, a limitation of goniometry is that it requires the clinician to use both hands, making stabilization of the extremity more difficult, and thus increasing the risk of error in reading the instrument. Inclinometry is another practical alternative that incorporates the use of constant gravity as a reference point to assess joint mobility. Digital inclinometers are portable, lightweight, and require training similar to that of goniometry. Digital inclinometer measures provide a quick highly reliable, valid, direct assessment of postural impairments such as trunk extensor muscle weakness or vertebral fracture [9]. To the authors' knowledge, digital inclinometer proposed in literature can only be used to measure flexion-extension angles in the sagittal plane and adduction-abduction in the coronal plane of standing or sitting subject for which these two anatomical planes are vertical. The internal-external rotation in the transverse plane which is horizontal in this case

cannot be measured by classical digital inclinometer as its operation is based on MEMS accelerometric sensor.

Block Diagram:



Conclusion:

A low cost digital inclinometer has been developed in our laboratory in order to measure range of motion simultaneously in the vertical and horizontal planes. Results can be displayed on the inclinometer screen or transmitted to PC where a GUI can provide a real time graphical display of the measured angles as well as a 3D-animation corresponding to the movement performed by the subject in 3D-space.