a prototype for the acquisition and analysis of the 3D mandibular movement

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The human mandible and the temporomandibular joint form a complex biomechanical system that performs several functions, and have the capacity to make high forces with great precision. In Dental Medicine is essential to know the mandibular cinematic to simulate the temporomandibular joints, to position teeth moulds in articulators, and to reproduce the mandibular movements in order to insure a satisfactory occlusion.

Currently, both commercial and academic devices are considered expensive and difficult to use in common clinical situations. Considering these disadvantages, it was developed a new system for the acquisition, visualization and analysis of the 3D mandibular movement that is economical, easy to use and sufficiently precise.

The development of the prototype system began with the choice of the technology to use in the 3D mandibular movement acquisition. Hence, electromagnetic sensors were used to measure the magnetic field created by a small magnet placed inside the patient's mouth (near to the incise point).

The selected sensors were the AA002-02 from *NVE Corporation*. As these sensors are sensitive in one direction in the plane of the integrated circuit it was necessary to use three sensors in order to acquire the 3D movement of the mandible. Thus, two circuit boards were specially developed in order to mount the sensors perpendicularly and to handle them more easily.

Instead of creating a new device structure, a common facial arc used in Dental Medicine was adapted as the main support structure. Among the commercial facial arcs the chosen one was the *Arcus* from *Kavo*.

As the selected arc was primary conceived to make static measurements, the first step in its adaptation was the redesign of the pieces that could difficult the dynamic measurement or harm the patient. Thus, the auricular pieces were redesigned.

Arcus facial arc from *Kavo*

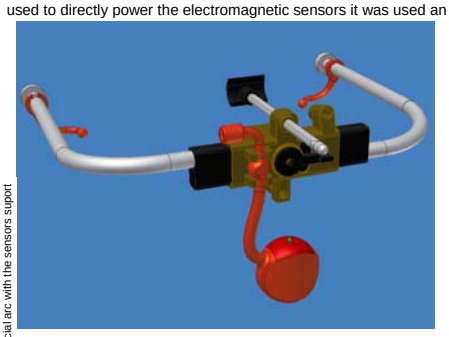
Auricular part

Redesigned auricular part

To attach the sensors support to the facial arc it was used an already existing groove in the same.

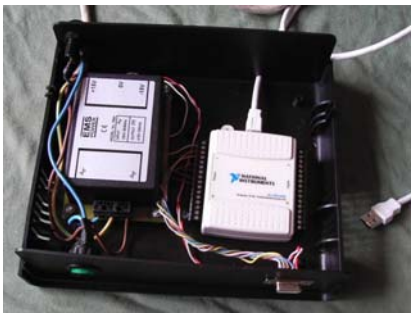
The two circuit boards developed are mounted in the sensors support by pressure; the access to the sensors boards is carried through a sliding cover, which has a hole for a led that indicates if the acquisition system is turned on or off.

For the acquisition of the sensors signals it was used a data acquisition device (DAQ) with plug-and-play USB connectivity, the NI USB-6008 model from *National Instruments*. In spite the DAQ selected could be used to directly power the electromagnetic sensors it was used an external power supply for that purpose instead.



Facial arc with the sensors suport

Prototype of the sensors suport



Box with the DAQ and the power source

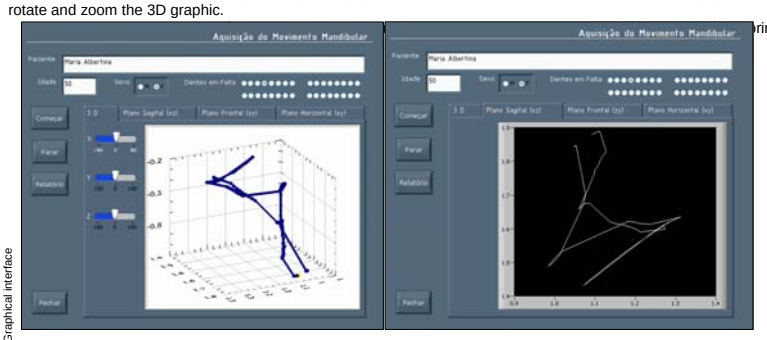
To know the 3D trajectory of the magnet, placed inside the patient's mouth, was necessary to convert the output voltage of the three electromagnetic sensors used in 3D cartesian coordinates. To solve this problem, a neural networks approach was used.

As generally the mandibular movement doesn't exceed the limits defined by a parallelepiped with 70 mm height, 40 mm length and 40 mm depth, it was registered the output voltage of each electromagnetic sensor at several calibration points. These points' coordinates and the associated three voltages were then used as "inputs" and "targets" to create and train the network used in the conversion voltages/coordinates. The neural network built was integrated in the computational application using the *LabVIEW*.

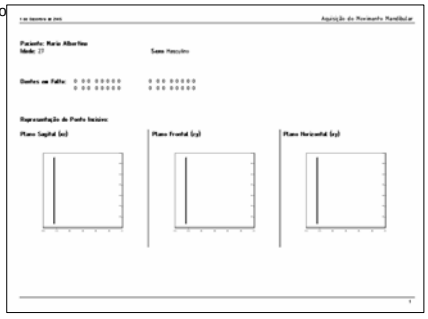
To make easy the acquisition and analysis of the 3D mandibular movement using a personal computer, it was build a new computational application with an adequate graphical interface using the developing tool *LabVIEW* from *National Instruments*.

The figures shows the interface of the developed application for our prototype system. In the upper part of the interface designed, the users can write the patient's personal data: the name, the age, the sex and the missing teeth. The control buttons of the application (start "Começar", stop "Parar", report "Relatório" and exit "Fechar") are placed in the lower part of the interface.

The results obtained are displayed using four graphics: one with the 3D movement, and three 2D graphics with the projections of the same movement in the sagital, frontal and horizontal plans. The user can rotate and zoom the 3D graphic.



Graphical interface



Report of the medical exam

The prototype system