# Posture Detection, Classifier and Correction System for Cyclists Applying KINECT V2 with Neural Nets and Fuzzy Logic

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The development of computer systems that analyze the execution of top athletes has been improving and becoming more meticulous and precise in an attempt to measure each variation that affects the performance of athletes. These complex systems are reserved, due in most part to their high costs and lengthy implementation process, to a few selected groups of athletes, excluding the amateur group, which represents a considerable population. The same happens with cycling, so the purpose of developing a low-cost, and rapid implementation system, is to conduct a larger group of people towards a comfortable riding posture and, consequently, to improve their performance.

The most common potential lesions in cyclists are backaches; at lumbar and cervical, both of which are related to an inadequate spine position due to its hyperextension while reaching the handlebar. Similarly, other conditions are present at the lower body such as severe pain in the thigh provoked by an external iliac artery, perineal nodular induration and other pathologies of the genitourinary system. Also caused by an inadequate seat height adjustment, whilst conditions regarding the knees, some stated by, are tendinopathy of the extensor apparatus and other pathologies of the internal and external rotators.

With the Kinect sensor, the recognition and display of the body's skeleton and joints, are easily achieved by its depth-sensing feature which is composed of an infrared projector, a camera sensor and a microchip built for tracking the movement of individuals in three dimensions. Overall, by being a non-invasive method, it generates a starting point for the development of a real-time system.

Thus, by recognizing the joints of the person, the angles between the involved limbs are estimated and displayed. Consequently, the values determined by the system provides the inputs for the neural net, returning the following posture classifications: Good, Fair, Poor and Deficient. The system then delivers the dimensions that should be adjusted for the bicycle based on the body characteristics of each user. Finally, after making the suggested mechanical adjustments, the described procedures are repeated in order to confirm that the new posture is fit and comfortable.

We began our development by evaluating the Kinect's SDK 2.0, which can detect up to 25 body joints. Our goal was to detect only the right side joints: knee, hip and elbow. Once the spatial coordinates (x, y, and z) are obtained, the system calculate the angles between the joints. To deduce the angle between two joints, it is necessary to consider three coordinate joint points located on the 3D space.

Considering the angle generated by the knee, hip and elbow the system classify the state of each joint, based on neural net of 50 neurons and 2 sigmoid layers which was trained with 20475 values. The cyclist posture is classified considering the angle ranges and divided into three segments: green (good posture), orange (short and long posture) and red (too short and too long postures). Finally, the mechanic adjustment measure was done by Fuzzy Logic. Once the knee, hip and elbow angles are measured, the stem length and saddle height are determinate with a defuzzification centroid method and three fuzzy controls for each measured angle.

The results of the experiment were positive. The system draws the angles in a blue color for a contracted posture of the cyclist. The angles are colored in red for a too extended posture, and green for a good balance. In the two incorrect postures, the Neuronal Network classify the posture as 'Deficient' and the Fuzzy Logic returns the parameters for saddle height and stem length to change, in centimeters. For the contracted posture, The system returns a value of 13.6 cm for saddle high and 10.6 cm for steam length, however, when the saddle high is corrected, the steam length correction is complemented. In the extended posture, the system returns a value of 8.5 cm to decrease in saddle high and a 3 cm to decrease in steam length, however, the when a saddle high correction is done, the steam length correction is complemented.

In a future work, the intention is to increase the number of sampled cyclists and link this investigation to existing projects in the city of Cuenca. The actual work shows some error due to the limitations of the Kinect sensor while detecting body joints, because of that, the motivation is to improve the way the system acquires the 3D skeleton.

# POSTURE DETECTION, CLASSIFIER AND CORRECTION SYSTEM FOR CYCLISTS APPLYING KINECT V2 WITH NEURAL NETS AND FUZZY LOGIC

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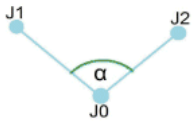
## Abstract

This study presents a posture-classifying system for cyclists using Kinect for skeleton detection; a neural net classifier; and fuzzy logic for parameters adjustment.

User posture has been rated in terms of "good", "fair", "poor" and "deficient". Said correction indicated in centimeters, refers to the bicycle seat height and to the length of the handlebars in order to achieve proper ergonomics.

The most common conditions in cyclists are backaches; at lumbar and cervical, both of which are related to an inadequate spine position due to its hyperextension while reaching the handlebar. Other conditions are present at the lower body such as severe pain in the thigh provoked by an endofibrosis of the iliac artery, perineal induration and other pathologies of the genitourinary system. Also caused by an inadequate seat height adjustment.


## Skeleton Detection And Joint Angle Measurement

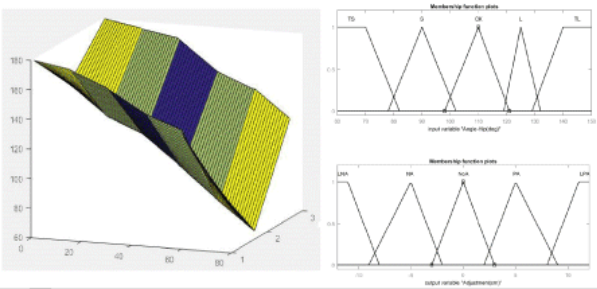



$$V_1 = (x_1 - x_0, y_1 - y_0, z_1 - z_0)$$

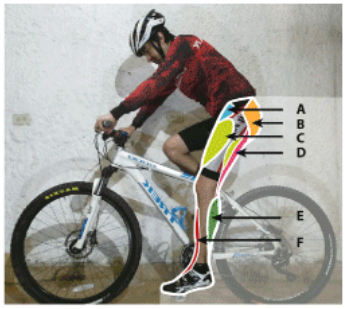
$$V_2 = (x_2 - x_0, y_2 - y_0, z_2 - z_0)$$

$$\propto = \cos^{-1}\left[\frac{(x_1 - x_0)(x_2 - x_0) + (y_1 - y_0)(y_2 - y_0) + (z_1 - z_0)(z_2 - z_0)}{|V_1||V_2|}\right]$$

## Posture Classification With Neural Nets & Mechanical Adjustment Measure Applying Fuzzy Logic

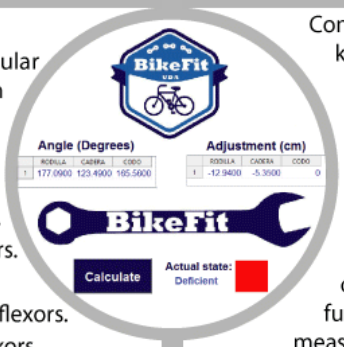


## Bikefit Biomechanics




Lower limb muscular group involved in cycling exercise:

A. - Hip flexors.
B. - Hip extensors.
C. - Knee extensors.
D. - Knee flexors.
E. - Ankle plantar flexors.
F. - Ankle dorsiflexors.




Considering the angle generated by the knee, hip and elbow the system classifies the state of each joint, based on ranges that will be the training parameters of the Neural Net. Once the knee, hip and elbow angles are measured, the stem length and saddle height are determinate. In order to do this, a defuzzification centroid method is applied and three fuzzy controls are implemented for each measured angle.

## Tools And Machines

Some of the applied tools to perform bikefit are basic tools like measuring tapes, graders, level, plumb lines and static rollers, which are used for specific applications.
Other machines also includes precision tools and artificial vision like the Trek Precision Fit o Retul Muve SL Dynamic Fit Bike. This precisions machines are considerably expensive.

## Evaluation

## Proposed Method

The skeleton and joint detection is executed with Kinect's SDK 2.0, which can detect up to 25 body joints, including palms and thumbs. Working with cycling posture, the system focuses only on the right side joints; knee, hip and elbow. Once the spatial coordinates (x, y, z.) are obtained, the system calculates the angles between the joints.

## Conclusions

- A good posture on the bike increases an athlete's performance and decreases the chance to suffer injurie.
- A low cost system could increase the number of users and permit the amateur group to be benefited.
- It is necessary to develop a correction method to acquire the 3D skeleton in a more accurate way.