Musculoskeletal ultrasound imaging is an efficient and effective method for the measurement of functional and architectural muscle parameters. It was shown that morphometric and architectural parameters are correlated to muscle contraction; hence they reflect dynamic and mechanical properties.

Skeletal muscle ultrasound is a reliable technique used for the evaluation of muscular, tendon and joint disorders. The evaluation of skeletal muscle architecture is generally qualitative or semi-quantitative. A quantitative approach to the assessment of ultrasound images is to measure parameters such as muscle thickness, pennation angle and fascicle length.

Traditionally, muscle thickness, pennation angle and fascicle length are manually detected in ultrasound images by an experienced operator. Muscle thickness in the longitudinal plane is defined as the distance between the superficial and deep aponeuroses, while the pennation angle and fascicle length are respectively defined as the angle between the muscular fascicle and the deep aponeurosis and the length between the insertion of the fascicle into the superficial and deep aponeuroses.

However, manual measurements are time-consuming and subjective: in fact, an operator takes at least ten minutes to make a measurement and the final result depends on the method used to estimate these parameters. In literature there are also semi-automatic methods to perform these tasks but they require a manual initialisation to operate correctly and for this reason they are still time-consuming.

This thesis presents the MUSA (Muscle UltraSound Analysis) algorithm, which allows the automatic detection of the muscle aponeuroses in longitudinal ultrasound images. In particular it is developed to process images of the medial gastrocnemius, vastus lateralis, rectus femoris and tibialis anterior. Once known the position of the aponeuroses, the algorithm estimates the average muscle thickness. Moreover it detects the fascicles in the muscle, and it estimates their pennation angle and length.
The MUSA algorithm takes as input the longitudinal image in DICOM format generated by the ultrasound scanner and, through a series of processing steps, the algorithm follows three different phases for the evaluation of the muscle thickness:

1. creation of a binary mask containing all the possible aponeuroses;
2. search for the two real aponeuroses through an optimized heuristic process;
3. estimation of muscle thickness.

For the evaluation of the pennation angle and fascicle length, the MUSA algorithm follows three steps:

1. identification of all the possible fascicles within the muscle;
2. elimination of the fascicles considered incorrect through classification and geometrical rules;
3. calculation of the pennation angle and fascicle length.

The algorithm is tested on 200 images to verify its reliability in estimating muscle thickness. The results show how the automatic method is precise and accurate compared to manual measurements. Moreover, the algorithm is tested preliminarily on 30 more images, in order to assess the automatic recognition of fascicles. The results obtained for the fascicle detection are promising to encourage further study, because the algorithm is effective in the identification of fascicles even in images where they are not clearly visible.

This algorithm, unlike the manual method, allows to perform quantitative measurements in a completely automatic way, with repeatable results and within a few seconds.

The MUSA algorithm could be in the future the basis for a functional evaluation of the muscle through kinematic analysis, providing quantitative data about changes in muscle configuration during movement.