The aim of this project is to develop a method for reconstruction of the sound speed in soft tissues during ultrasound imaging. The sound speed in soft tissues varies from approx. 1460 m/s in fat to over 1600 m/s in muscles. In standard pulse-echo ultrasound imaging the exact sound speed in tissue is unknown and therefore, for the purpose of image reconstruction, it is assumed to be uniform and equal to 1540 m/s. This obviously leads to aberrations i.e. decrease in image quality: blurring, loss of contrast, geometrical deformations, etc.

A method for reconstruction of the sound speed in ultrasound imaging will provide the basic information on the examined tissue. This new information, unavailable so far in medical pulse-echo ultrasound scanners, may be utilized in a number of ways. Firstly, it will make possible to enhance the quality of the reconstructed images in ultrasound pulse-echo imaging systems. Such devices are widely used in medical diagnostics due to their non-invasiveness, harmlessness, versatility, time resolution and relatively low cost. Substantial reduction of aberrations in such a well established imaging technique will definitely contribute to the increase in quality of the diagnostic process. Secondly the sound speed carries information on mechanical properties of the examined object. Therefore, the calculated sound speed maps may provide additional diagnostic information.

Moreover, the field of use of the sound speed information is not limited to medical applications. The method for sound speed reconstruction can bring similar benefits in nondestructive testing (NDT). Development of a method for reconstruction of a sound speed for pulse-echo ultrasound may have positive impact on many areas such as medical diagnosis, quality control in industrial applications (post-production quality control of welds, defect inspection, etc.) and procedures for safe exploitation of infrastructure (e.g. testing of the condition of rails and railway wheels and axes, structural elements of buildings, etc.).

Several methods were proposed for correcting the aberrations due to improperly chosen sound speed. Some techniques are based on an assumption of existence of a phase screen i.e. an irregular near-field layer that introduces additional time delays. The solution was to find and compensate for these delays. Another approach involves multiple image reconstructions with various sound speed values assumed. The sound speed used for reconstruction of the sharpest of the images is assumed to be the average sound speed in the examined object. However, the simplifying assumptions of the above approaches resulted in their limited efficiency. The latest solution utilizes time delays extracted from phase component of the reconstructed echo signals. Next, the time delays are used to calculate the local sound speed through solving an inverse problem by matrix inversion. Although this method brings promising results, it is computationally complex which prevents its use in real time systems unless the pixel resolution of the input image is greatly reduced.

The information about the sound speed distribution in an examined object is carried by the ultrasound signals that propagated through that object. According to the literature, this information can be extracted from the phase of the echo signals received from the object. We developed a mathematical model which makes possible to calculate the local sound speed at reasonable computation cost. The work in this project will be focused on verification and improvement of the proposed mathematical model as well as on optimization of its implementation.