Contactless identification of impact parameters for adaptive energy absorbers

Energy absorbers are widely present in people's lives, even though this may not be visible at first glance. They fulfil many tasks, which in many cases are aimed at improving people's quality of life, and in extreme cases at saving them. An energy absorber is, for example, a suspension damper in a car, which improves driving comfort. In its basic version such a damper is a passive device, which means that it does not change its operating characteristics depending on the conditions in which it has to operate. More expensive cars are increasingly equipped with adaptive dampers that dynamically change their parameters in order to adapt to the operating conditions, e.g. slow driving on a rough road or fast on a motorway. In applications less commonly seen on a daily basis, but still very important, it is possible to encounter an energy absorber used by a fire brigade team to protect people from the negative effects of jumping from a great height or during popular bungee jumping – the rescue cushion. It is a large airbag filled with air, which mitigates the negative effects of the sudden deceleration of a falling person. Airbags in cars have a similar mechanism of operation. The effectiveness of such systems can be greatly improved by allowing them to adapt to different impact conditions. However, this is a very complex issue.

There are two basic possibilities to recognise and adapt such systems to the impact conditions – during the impact process or before it occurs. Recognition of the dynamic parameters of the impacting object at the moment of impact is a relatively simple matter for absorbers of rigid construction. However, application of any adaptation method in such a case is troublesome, as the duration of the impact is usually very short. This limits the choice of adaptation technology to the very few existing solutions. In the case of low stiffness absorbers, such as rescue cushions, it may not be possible to recognise the impact parameters at the time of impact at all. The second way, i.e. recognition of the approaching object and its basic dynamic parameters even before the impact occurs, seems to be a much better solution. It gives the control system enough time to adapt the characteristics of the absorber to the recognised conditions. If even a second or half a second is gained in this way, this should be regarded as a huge gain, as the impact process usually takes much less time. Such a time allows to change the characteristics of the absorber, e.g. by changing the permissible gas flow through the valves with which it could be equipped. The second method described, however, has never been studied in such a context.

The aim of this project is to develop a method for remote, contactless recognition of impact parameters, even before the crash occurs. For this purpose, four basic techniques of object recognition and tracking will be considered – computer vision, as well as ultrasonic, radar and laser measurement methods. Each of these methods has specific advantages and disadvantages, so it is necessary to initially consider the applicability of each of them. Computer vision is an extremely broad field of research, requiring an exhaustive review of the available methods with regard to their applicability in project work. The other three measurement methods are not as extensively covered in the scientific literature, but each represents a distinct field of engineering in which many measurement and object identification methods have been proposed.

The effectiveness of each of the selected measurement methods will be verified in a reproducible manner on special drop test facilities. They will allow a selected type of object to be dropped from two different heights, which will also verify the scalability of the measurement methods used for different impact conditions.

The main objective of the project is to create a method of identifying the dynamic parameters of an object approaching the absorber before impact. This will allow it to adapt its characteristics well in advance, mitigating forces acting on the object while avoiding the problems associated with trying to adapt them during impact.