Abstract
Today, an aging society puts new financial strains on health insurances. Since self-organized ambulant medical care is less expensive than admittance to the hospital, maintaining the patient’s automotive mobility is an important factor to reduce costs. Also, the automotive environment itself can be used to deliver medical care or prevention to the patient in his accustomed environment. For instance, a derived electrocardiogram (ECG) can be used to detect or regularly monitor heart diseases while driving, i.e. to prevent accidents. For practical reasons, contactless ECG measuring systems, such as capacitive coupled cECG systems, are beneficial.
In the report, a survey on automotive healthcare applications and in particular the development of cECG systems for the use in automotive environments is given.

Introduction
In 2008, the German community spent a total of 66.7 Billion Euros for stationary treatment of patients in hospitals. The amount was almost equally split between patients of two age groups: Young citizens aged 64 or younger (34. Billion, 51.4%) and senior citizens 65 or older (32.4 Billion, 48.5%). Expenses are expected to rise only moderately to 75.5 Billion in 2030 (+13.1%) [1]. However, due to Germany’s aging society, costs inflicted by senior citizens will account for approx. 60% of total expenses in stationary care, putting strains on health insurances and the decreasing German working population in general. Therefore, to maintain the current healthcare quality, actions have to be taken to reduce costs.
A conceivable solution might be the transformation of a part of healthcare given today in stationary care into ambulant care, which is more cost effective. Being a general principle in German healthcare already, this approach should be intensified.

Motivation
Ambulant healthcare inherently requires more transportation services than stationary care as the patient has to come to the doctor, not vice versa. Therefore, the patient’s ability to safely and conveniently travel between his home and the ambulant healthcare site is an enabling factor. Potential solutions include public transportation, assisted and un-assisted individual traffic.
Public transportation is not a solution due to the lack of door-to-door transportation services required by elderly, possibly handicapped patients. Assisted individual traffic offering door-to-door services is however more expensive. Therefore, individual traffic, that is, the patient himself driving to ambulant care sites is the only feasible and cost-effective transportation solution.

However, due to the reduced mental and physical abilities of elderly people, compensatory assistance must be provided to ensure save traffic participation. Also, for frequent traffic participation, psychological inhibitions due to reduced self-confidence and trust in one’s own driving abilities must be overcome.
One particular good example of diseases leading to reduced physical abilities and self-confidence are diseases of the cardiovascular system such as a heart attack, ventricular fibrillation, or sudden cardiac death. Firstly they may cause situations of acute danger, i.e. a car accident due to unconsciousness. Secondly, patients may suffer from symptoms of post-traumatic stress after having had a heart attack while driving. This may lead to a reduced willingness to travel by car. Therefore, an appropriate monitoring of heart diseases while driving can be beneficial for accident prevention (i.e. automated brake system) and encouragement of the driver, i.e. by giving feedback concerning his cardiac status. One well established method to monitor cardiac activity and diseases is an electrocardiogram (ECG).

**Contactless monitoring of the electrical heart activity**

Conventional ECG measurement systems use a galvanic coupling between the patient’s skin and the ECG electrode to measure the electrical voltages present on the skin due to the electrical heart activity: An electrically conducting, resistive connection exists. In contrast, capacitive ECG (cECG) make use of the electrostatic induction of the electrical field. Due to this effect, voltages present on the skin can be measured without direct electrode-skin contact which was first described in 1967 by Richardson [2]. As the electrical field can also pass other materials than air, cECG measurements can also be performed through clothing. No electrodes have to be stuck or otherwise attached to the skin. It is sufficient to place the electrodes in proximity to the skin. This is very beneficial in automotive environments as the electrodes may simply be integrated into the car seats. However, variation in the coupling distance will lead to motion artefacts diminishing signal quality. Such motion artefacts [3] can in particular be expected in an automotive environment with severe vibration generated by the engine or damaged roads. Therefore, a validation concerning the obtained signal quality is necessary.

**Feasibility study**

To assess the obtained signal quality in a real world driving situation, a feasibility study has been performed at the Philips Chair for Medical Information Technology in cooperation with Ford motor company. [4] cECG data was collected using 6 capacitive electrodes integrated into the driver’s seat as shown in figure 1. Recording setups included measurements in a stopped car with deactivated engine, driving in city traffic and driving on the highway. [4] For 86% of all drivers a reliable ECG could be obtained. With optimal dressing (single clothing layer, cotton, thin), this value increased to 95%. A correct heart rate could be obtained from the ECG data in 61% (city traffic), respectively 86% (highway traffic) of all drivers. [4] Thus, in suitable travelling conditions (highway), heart diseases can be properly monitored.

**Conclusion**

Aging societies such as Germany face economic challenges due to increased health spending and a reduced working population. Therefore, cost effectiveness must be enforced. One way out is the transformation of stationary into ambulant care. Maintaining individual mobility has been identified as an enabling factor for this approach. Monitoring the driver’s health and giving corresponding feedback can both prevent accidents and encourage the driver to maintain his automotive mobility by providing a sense of security. Capacitive derivation of an ECG (cECG) has been shown to be a proper monitoring modality for cardiovascular diseases.
However, cardiovascular disorders only cause a minor part of traffic accidents. Most accidents are caused by fatigue, inadequate speed and – particular in case of elderly drivers – excessive driving demands. Therefore, future research will also focus on fatigue detection and assistance systems reducing driver workload.

![Image](image.jpg)

Figure 1: eECG seat used in the feasibility study

References: