The Smart Tachograph

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ABSTRACT

Today's insurance rates are often only a rough approximation of the actual risks they insure, categorizing insurance takers into coarse classes based on long-term demographic facts such as age or address. This not only negatively affects the care with which the insured good is treated, but also often implies a significant amount of cross-financing from low-risk customers to high-risk customer. By being able to measure the risk an insured good is subjected to in real-time, insurers could offer real-time insurance rates that would both encourage safe treatment of the insured good, as well as reward low-risk customers with lower insurances rates. The video presents the Smart Tachograph, an example of such a real-time risk-measurement system in the car insurance domain. It further demonstrates vividly how a risky driving style could significantly increase an individual's insurance rate.

1. INTRODUCTION

Today's car insurance schemes typically divide drivers into about two dozen different risk categories, using only a few criteria such as the driver's age, gender, driving experience, place of residence, or car model. While all these parameters are being determined before the insurance goes into effect, the actual behavior of the driver *after* signing the policy (e.g., a safe driving style) will reflect only slowly on his or her insurance rate, typically only after one or more years of accident-free driving. Moreover, since inside such a statical risk category the actual risks can still vary heavily, higher-risk drivers in a class are thus cross-financed by the lower-risk drivers [2].

These well-known problems of insurance markets are called *moral hazard* and *adverse selection*. Moral hazards describe an insurer's lack of control over how careful a customer handles the insured good, while adverse selection denotes the cross-financing from low risks to high risks that takes place within a heterogeneous customer group. Both of these effects are ultimately based on the *information asymmetry* often found in insurance markets. This phenomenon, first described in an influential article by George Akerlof [1], refers to one market side having more or better information about the traded good. In the context of insurances, it represents the insurers' lack of information about the actual behavior of their customers.

The deployment of ubiquitous computing technologies might significantly reduce this information asymmetry. This is because autonomous sensors and tiny microcomputers could allow for a much more detailed and often even real-time observation of real-world phenomenons: a smart shirt might observe how "healthy" a person eats (and thus instantaneously adjust the corresponding life insurance rate) while a smart car could analyze the individual risks a customer might take on a particular stretch of road (and increase the insurance rate per kilometers accordingly). Our Smart Tachograph prototype aims at demonstrating this effect.

2. REAL-TIME RISK ESTIMATION

Estimating the probability of being involved in a car accident (and the subsequent costs if that event occurs) is obviously no trivial task. Commonly used criteria such as driving experience, age, or car model most certainly affect the risk of being involved in a traffic accident. However, more ephemeral factors also contribute significantly to the overall risk, such as the type of road driven on, the time of day, weather and light conditions, speed, acceleration, distance to the car in front, and last not least the drivers physical condition. Driving one kilometer on a straight highway on a sunny Sunday afternoon is typically less accident prone than a one kilometer, bumper-to-bumper drive in a wintery city center during evening rush hour.

Such instantaneous factors make a great difference between drivers that otherwise are equally "good" (i.e., who are in the same class of drivers according to today's typical classifications). As this type of data had previously not been ascertainable with sufficient accuracy, insurers consequently had to neglect this information. By being able to determine these factors, insurers could eliminate much of the cross-financing within an insurance class and provide a substantial monetary incentive for safe driving, ultimately charging every customer only for his or her personal risk.

Such a model would have a number of advantages over today's status quo. Firstly, insurers offering such schemes could gain market shares in the interesting segment of low-risk drivers (by being able to offer them much lower rates), as well as getting rid of their bad risks (since they would have to pay higher premiums to stay) [2]. Secondly, the majority of customers would profit from such a risk distribution, as a large number of safe drivers typically cross-finance a few risky drivers. Thirdly, such an approach might also have positive side effects on the overall traffic security and the environment, as customers would more carefully chose how often and under which conditions they drive, thus reducing road congestions.

3. THE PROTOTYPE

To demonstrate the idea of momentary insurance premiums that depend not only on the age or experience of drivers, but more on the circumstances and manner in which they drive, we have built a prototype – the *Smart Tachograph*. The smart tachograph's hardware consists of a collection of sensors that have been placed in a plastic box underneath the car's windshield: a wireless GPS unit and a sensor board carrying two accelerometers (for longitudinal and cross acceleration), a temperature, and a light sensor. The data gathered by these sensors is sent via Bluetooth to a laptop computer running the smart tachograph's software. The laptop can be placed anywhere within the car.

On the laptop computer, the sensor information is then analyzed and displayed. In our test setup, the interface consists of three components. The main program window is needed to setup and start the system. Several parameters can be set here. Among them the driver may choose an insurance company and a price scheme out of the available offers, thus implementing the idea of a ride-by-ride insurance proposed in [2]. The second window presents the sensor data as a collection of bars. The raw GPS coordinates are translated into the actual street that's been driven on using a commercial geospatial database. Knowing the speed limit for all streets in the administrative region of Zurich, we can display this information on one of the bars and use it, together with the actual speed, for risk approximation. The actually driven speed is also inferred from the GPS data, as distance traveled over time. In a real-world deployment, this information could of course be gathered directly from the speedometer. Our method is surprisingly exact though. The lower bars show the data from the other sensors – longitudinal and cross acceleration, temperature, and light intensity. The data from all these sensors, as well as the GPS coordinates are ascertained and transferred to the laptop once every second.

The third interface window would probably be the only one shown in a real deployment. It shows the current insurance rate (expressed in Swiss cents per kilometer), which is continuously calculated on the laptop computer from the received sensor data. The indicator presenting this aggregation should be perceived by the driver similar to the momentary gas consumption indication built into some cars. It allows the driver to receive instant feedback on how his or her driving style influences the insurance rate.

The formula that converts the sensor data into an accident probability and subsequently into a momentary insurance rate is quite complex. It starts with a minimum insurance price per kilometer. This minimum is not fixed, though, it varies with the street type. A highway kilometer, for example, is less expensive than a city kilometer. In a real deployment, this minimum would presumably also depend on the "classical" risk factors such as driver age or experience, which are used today to classify customers into driver categories. Several exponential functions are then multiplied with the basic price. Their respective bases are: the difference between driven and maximum allowed speed, the longitudinal, and the cross acceleration. These functions have low exponents, ranging from 1.05 to 1.20. Since a driver must be able to accelerate, brake and take curves in a secure manner without being penalized, all exponential functions have thresholds. When staying within these thresholds, there is no addition to the basic price.

4. DISCUSSION

A system such as the smart tachograph could be deployed with little extra effort in state-of-the-art cars. A modern car comes with a variety of sensors, including all sensors that have been used for our prototype. It is equipped with acceleration sensors for the electronic stability programs, with a temperature sensor for signaling the driver a possible slippery road, and with light sensors for automatic headlight activation. Most middle- to high-end cars are also equipped with a GPS sensor and navigation maps. All these sensors that have been placed in cars for other reasons could be reused for a system such as the smart tachograph.

Apart from the sensors used in our example, many modern cars come with a variety of other sensors that could be used to measure the incident probability even more accurately. A distance sensor used in many cars as parking aids could be reused to measure the distance to the car in front. This information, correlated with the type of street and driven speed, is a major determinant for the current risks taken while driving.

Through the modular software design, the smart tachograph not only allows additional sensors to be easily included. It could also be used in a smart *road pricing* scheme, to regulate vehicle taxes on a pay-per-use basis. This could, for example, penalize those who drive during peak traffic times or when ozone levels ar high.

Two obvious questions raised by the smart tachograph are about societal fairness and privacy protection. There are several well-known examples of costs that could easily be allocated to their originators, yet they are burdened by the society as a whole, such as health insurances in western Europe. It would be rather simple to evaluate the individual risk of illness based on age, gender, and health history. Yet, elderly or people with chronical diseases could then hardly afford a health insurance. Many countries have decided instead to spread those costs throughout the society, willingly cross financing the ones rather prone to illness from healthy society members. At a first glance, driving a car doesn't seem to have the same societal value as health; an exhaustive socio-political consideration would yet undoubtedly benefit the discussion.

Privacy protection is a crucial issue with such omniscient insurers. Although possible, we therefore did not choose to send all measured data online to the insurer. Instead, the data is analyzed locally on the vehicle's computer using a formula provided by the insurer when the contract has been signed. The insurer ultimately receives only a sum at the end of the month. If that sum is high, the motorist might have driven a rather short distance in a risky manner or a large distance in a secure way. The insurer will not know. Of course, all information being processed locally arises the risk of sensor and/or software tampering by the vehicle owner. Discussing these issues is outside the scope of this paper though.

The use and implications of smart insurance schemes have already been analyzed in several other places, e. g. [3, 2]. Insurance companies have also shown interest in the field. Progressive, a US-based insurer, developed first simple prototypes as early as 1998 and offers a distance- and time-based insurance since 2004.[1] Norwich Union, a UK insurer, has similar plans.[2] Both insurance companies, however, seem to have chosen a privacy-invasive solution (all sensed data is transmitted to the insurer). Furthermore, both systems are rather simple, depending mainly on distance and time of travel.

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