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The optimization of a product's Touch-Feel

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Touch-Feel Management Summary 1/2

The design of **surfaces exhibiting a desired "Touch-Feel"** has become a major issue in many industry branches. These comprise the automotive sector, consumer electronics, Fast Moving Consumer Goods and packaging to name a few. Nowadays products not only need to meet the aesthetical taste of the consumer concerning their optical appearance but also need to **satisfy the demand for the correct "Touch-Feel"**. To enable the production of surfaces with the desired touch feel in a targeted manner requires a **detailed knowledge of all surface and material properties**, which in their complex interplay evoke the desired tactile perception. To understand and control these interrelationships, the **Polymer Competence Center Leoben GmbH** has set up a research initiative which, since 2014, has focused exclusively on the "Touch-Feel", the necessary technologies for surface measurement and -characterization and the data processing in the production.

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Touch-Feel Management Summary 2/2

Possibilities of PCCL technologies – our offer:

The production of a **product surface with the desired "Touch-Feel"** often involves a complex process. The knowledge of the **connection between the tactile perception and the triggering surface and material parameters** opens up various possibilities for the targeted optimization of the "Touch-Feel" of surfaces and manufacturing processes. With the methods developed at the PCCL, material parameters can be specifically varied to generate the appropriate "Touch-Feel" for each product in an economical and ecological way. Furthermore, it is possible to test whether a certain product surface is suitable for the intended area of application (automotive, home and consumer electronics, packaging, ...) and to make an objective comparison of the "Touch-Feel" of an imitation and an original possible.

In cooperative projects, based on the developed measuring possibilities of the PCCL, the data evaluation by means of AI and the know-how created, problems of the industry are to be solved efficiently.
The PCCL GmbH is excellently positioned for this!

What is Touch-Feel?

The human **sense of touch** is highly developed. It enables the recognition and evaluation of the finest topographic structures. The sense of touch can also check materials for slippage and detect the thermal conductivity of a material. The totality of these parameters is combined into a **tactile impression**, which manifests itself in a perception that is sometimes referred to as soft-touch, leathery, silky, froggy, etc. Since the "Touch-Feel" is caused by physical surface and material parameters such as roughness, hardness, texture, etc., a connection between surface properties and perception can be created with the correct selection of measurement parameters and evaluation methods. This relationship is shown in Figure 1.

In addition to the purely **physical parameters**, the touch feel of product surfaces is also determined by the **respective application**. A product surface can therefore be perceived and evaluated differently in different **tactile scenarios**.

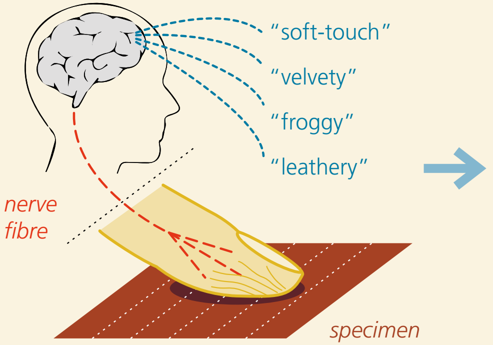

Fig. 1a: Process of tactile perception

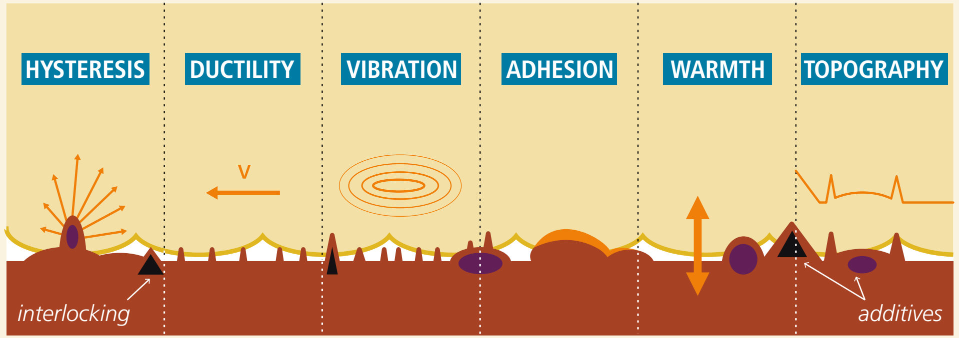

Fig. 1b: Physical surface and material parameters as well as parameters resulting from interaction

The most important physical surface and material parameters as well as the parameters resulting from interaction are shown in Figure 1b. The skin dynamically scans the surface and records the surface and material parameters with a series of receptors (not shown). Nerve lines transmit these to the brain, where they are analysed and specific tactile impressions of the surface occur. In the case of known materials, a material type can be assigned to the test sample.

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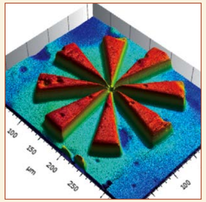
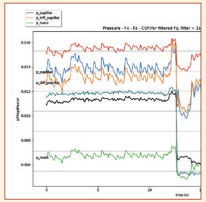
Touch-Feel measurement: influencing factors

Topography



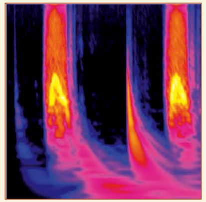
The topography of the samples is measured using the interferometric principle, where a vertical resolution in the single-digit nm range is achieved. Topography plays an important role in all the parameters presented, which is why high-precision measurement and evaluation is essential.

Friction



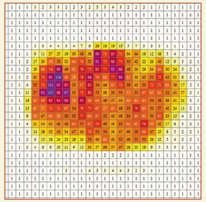
The coefficient of friction is the most important parameter with regard to the feeling of slippage of a surface. In addition to the pure mean value of the coefficient of friction, other statistical parameters are of importance.

Vibrations



The vibrations generated by the relative movement between the finger and the sample are the most important parameters for the perception of roughness and texture. The data is evaluated with regard to various statistical parameters such as power, expected wavelength and amplitude distribution.

Pressure distribution



The pressure distribution of a finger can be measured statically and dynamically. This allows a deeper understanding of the tribological processes and the elastic properties of a finger.

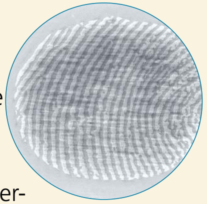
Heat transfer

The heat transfer between the finger and the sample is determined by the heat capacity of the material and the contact surface. This parameter determines the tactile hot/cold effectiveness of surfaces, a critical factor for the discrimination of different materials.

Skin moisture

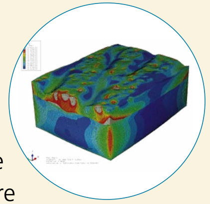
The knowledge of the moisture of a finger is a necessary prerequisite for a meaningful tribological characterization of a surface.

Contact area



The contact area between finger and sample determines to a large extent the friction forces (adhesion) and the temperature sensation. The evaluation of contact area data (using artificial intelligence) enables the evaluation of the true contact area during the relative movement between a finger and the specimen.

Simulation

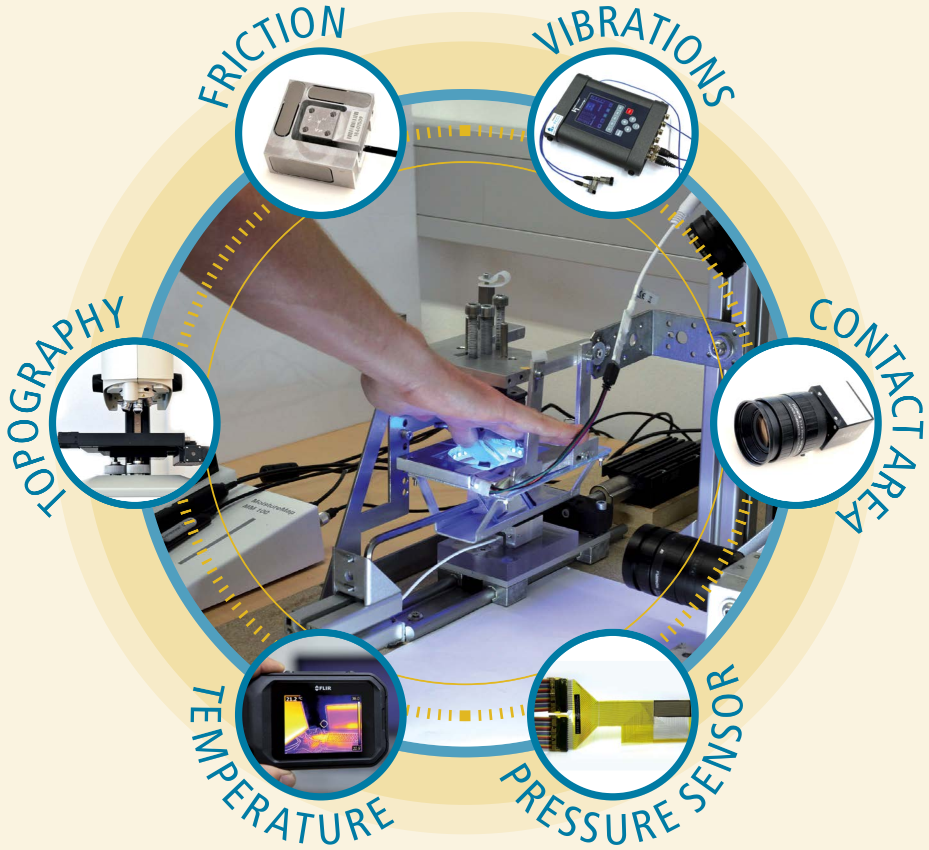


The contact parameters such as contact area, force and pressure distribution between the finger and the surface are simulated using the finite element method. This enables the detailed capture of the effect of surface properties on the human finger.

Touch-Feel measurement: the PCCL measuring stand

The PCCL is optimally equipped with regard to the metrological recording of the above-mentioned parameters. In order to guarantee reproducible measurements, which can be carried out under controlled conditions, **a "Touch-Feel" measuring stand has been developed**. With the measuring stand all relevant measuring parameters can be measured simultaneously and with high accuracy. **This is a prerequisite for a successful quantification of "Touch-Feel".**

In order to obtain meaningful results, all data obtained must be combined and statistically evaluated. The PCCL has many years of experience in the analysis of large amounts of data and their evaluation using neural networks. Specialisation in methods of artificial intelligence, including the acquisition of the contact area, has led to **unique selling propositions, such as real-time contact area acquisition**.



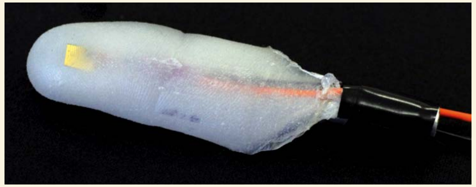


Fig. 2: Artificial finger

Artificial finger

The PCCL has developed an artificial finger whose surface structure and viscoelastic properties are very similar to those of a human finger and which is equipped with sensors.

Fig. 3: The interaction between the finger and the surface reveals four dominant classes of influencing parameters:

1) Friction
2) Vibration
3) Contact area topography
4) Heat transfer

Touch-Feel Measurement: Experience Studies

In order to investigate the "Touch-Feel" of surfaces, the samples are examined in experience studies regarding their tactile effect and quality. In the course of a strategic PCCL project, the **Material Experience Lab** was founded in cooperation with the Center for Technology Experience at the AIT (Austrian Institute of Technology GmbH) in order to investigate the influence of different application areas and environments on the perception of material properties.

In a **virtual reality environment** different contexts are simulated and their effect on material perception is investigated. This enables the perception of materials to be placed in the context of a concrete use case and thus the applicability of the results for later use in the real application environment to be evaluated.

Fig. 4: The illustrations on the right show the use of soft-touch surfaces in the context of car interiors and laptops.

The benefits of artificially generating knowledge from experience

The aim of the evaluation is the connection of the metrologically recorded influencing parameters with the tactile perception. This consists of basic sensations such as hard/soft and rough/smooth, etc. Certain combinations of these sensations ultimately lead to specific perceptions, called for example "leathery", "soft-touch", "velvety", "woody", "rubbery" or "silky", which, if successfully correlated, lead to a complete classification and predictability of surface sensations. A machine-learning neural network learns from examples in which the relationships between the physical/chemical properties of a surface and the tactile perception it produces are known (labeled) and generalizes them in the course of a training phase. Therefore, the trained neural network has an understanding of the interrelations and the effect of the influence parameters and can predict the expected tactile effect of new surfaces and support the evaluation of new surface variations. This creates an efficient and cost-effective possibility to test new coating variants before their costly experimental realization with regard to the properties to be expected. With the experience gained, the machine can even perform classifications in new, unknown data sets and make predictions for the expected results.

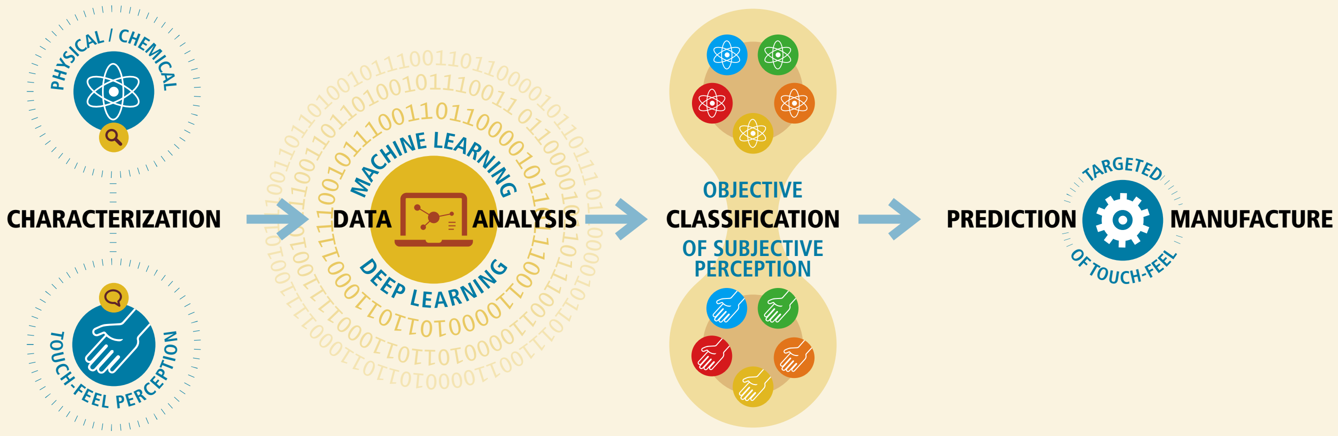


Fig. 5: Quantification of "Touch-Feel", starting with the measurement of physical and chemical parameters and the tactile classification of the surface or coating. This stage is followed by data analysis, starting with a feature extraction performed by a machine learning neural network. Once the training phase has been completed, the system is able to independently detect surfaces and predict tactile effectiveness based on the experience gained.

Cooperation / Contact

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Cooperation within the framework of

contract research

cooperative R&D within a PCCL COMET project

cooperative R&D within a sponsored research project

Dieter P. Gruber

Dr. Dieter P. Gruber completed his studies in technical physics at the Institute for Theoretical Physics at the Graz University of Technology in 2000. Due to his education in both materials physics and IT, his research focuses on surface physics, the characterization of material properties and the processing of large amounts of data using artificial intelligence. After stations at the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg Dieter P. Gruber followed the call to the Polymer Competence Center Leoben (Austria) in 2003. Since 2010, new "Machine Vision" methods and measuring methods for characterizing the appearance and tactile effect of surfaces have been developed under his leadership, taking into account human perception behavior. The habilitation took place in 2015 at the University of Leoben. In 2014 he was elected Austrian of the Year in the category Research. He has been awarded numerous research prizes such as the Magna ACS Innovation Award 2013, the Houska Prize 2014 and the Fast Forward Award 2018.

Thomas Ules

Dr. Thomas Ules completed his physics studies at the Karl-Franzens University Graz in 2015. He extended the research on the electronic structure of organic molecules at the University of Graz until 2016. Since 2017, Thomas Ules has been researching in the "Touch-Feel" department of Dr. Dieter P. Gruber at the PCCL on methods for the parameterization of tactile perception by means of measurable parameters. The tactile feeling of surfaces is brought from a purely subjective level to an objective measuring parameter level.

Participating PCCL researchers

Dr. Sandra Schlögl, Werkstoffe und Chemie
Dr. Andreas Hausberger, Tribologie
Stefan Mayrbrugger, Topografische Messtechnik
Michael Grießer, Optische Messtechnik

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