Method for observing the Rubber Stud Deformation

Application in Trailrunning

Trailrunning a sport in constant development with an increasing number of athletes in Europe and the World. It consists in running in the outdoor, in forests, in the mountains, on some hills, staying on the paths or not.

Rubber stud ensures safety and control to the runner, enabling adherence on all types of surfaces.

Trailrunning in numbers 2013 - 2019

1,77 Million Competitors

25,700 Races

195 Countries

Problem the behaviour and the deformation of the rubber studs and the relative adherence are imprecisely known as the observation from under the shoe over a rough surface is not possible.

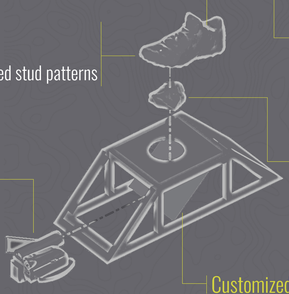
New method developped to observe that deformation and have a better understanding of the interaction shoe / ground.

Idea : Observation through a transparent stone

- Filming the stud deformation and recording the loads applied on it
- Computing the light deformation
- Measuring the position of the studs, the area of contact, the forces and momentum during a footstrike

Shoe

With colorised stud patterns



TUM Tracktester

A biomechanical test bench to simulate a stride over different grounds under realistic loads and movements

previously developed at the laboratory

Moulded transparent stone

Material: Epoxy resin
Model: Natural stone

Process self developed

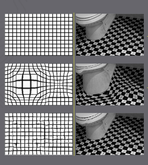
4K Camera

Customized mirror

Correcting the light deformation

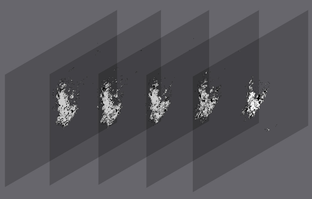
The strong light deformation was corrected using a scaling grid and an intern-developed software. A bilinear interpolation method was used.

Precision: 0.25 mm



The contact area: a pioneering result

With image processing methods, the hsv spectrum of the pixels where the shoe enters in contact with the stone was used to determine the contact area at each moment of the experiment. This wasn't done until now on uneven surfaces, mainly bescause of the problem of the light deformation.

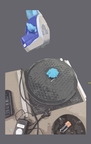


Evolution of the contact area during the experiment

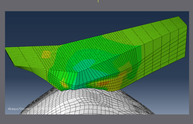
Creating a finite element model for comparison

To compare the experimental results with today's development tools, a finite element model was carefully developed to point out the differences between reality and simulation.

3 D Scan of stone and stud



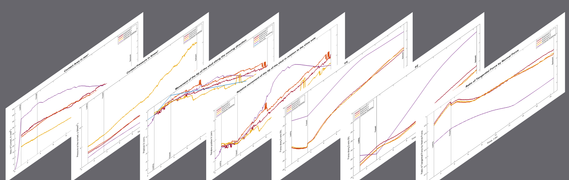
Properties of the rubber material determined and friction test between rubber and stone



Computer modelling in the commercial software Abaqus

Results

The results measured in experiment have been compared to the ones obtained by computer modelling. For the loads applying to the stone, the graphs have shown similarities in their shape and maximum values. For the displacement it has shown that the tip of the stud has more adherence in experiment as in the model. This comes from the fact that the 3D model was limited in precision due to the computer hardware and the microproperties of the surface. The latters are playing an important role in adherence. Finally a big difference has been noticed in the contact area, where it was observed that a lot of holes were not in contact with the rubber stud in reality, which wasn't the case in the model. The contact area is then overestimated by the software. As it is an important factor for adherence, further research in this direction should help understanding the physics under that phenomenon and help trailrunning companies to bring better and safer shoes to the market.



References:
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'"COMPARATIVE STUDY OF SHOE-SURFACE INTERACTION IN TRAIL RUNNING - SUBJECTIVE AND OBJECTIVE EVALUATION" by Bahador Keshvari, Veit Senner et al.' https://commons.nmu.edu/isbs/vol35/iss1/210/ (accessed Jun. 09, 2020)
B. Barry and P. Milburn, 'Tribology, friction and traction: understanding shoe-surface interaction', Footwear Sci., vol. 5, no. 3, pp. 137–145, Sep. 2013, doi:10.1080/19424280.2013.797030
Glastein software from Jürgen Mitternach

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