A METHODOLOGY FOR OBSERVING THE DEFORMATION OF RUBBER STUDS WHEN STEPPING ON A STONE

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Introduction: Trailrunning is an outdoor sport that consists in running in nature instead of on asphalt roads. The variety of terrains is thus very large. More and more recreational athletes are motivated by trailrunning in recent years and on the competition side the number of runners worldwide who have an International Trail Running Association (ITRA) Performance Index doubled from 600,000 to 1,170,000 between 2015 and 2019 [1]. An important aspect for the safety of the trail runner is the outsole of the shoe and its rubber studs that are bringing adherence on different type of surfaces, and especially on stones, where any fall can lead to an injury. Other authors [2] already studied the deformation of rubber over uneven surfaces using a transparent rubber. The aim of our study is to establish a methodological framework to observe and quantify the deformation of a chosen rubber stud in two dimensions during a predefined load pattern on a chosen stone object. In addition it specifies a method for detecting the shape of the surface and its area (A) which is in contact with the stone surface at any moment in time during the loading. The loading was done using the TrakTester developed at the TU Munich[3].

Methodology: Different stones were chosen in the nature and reproduced with epoxy resin from Dipoxy® Germany [4]. In order to replicate the asperities of the stone and to have a clean surface, a mould for each stone was conceived with modelling clay and a thin plastic foil. Only the expected sole contact area of the surface of the stone was replicated. The result of this process was a truncated transparent stone. The studied shoe was the Scott Kinabalu 2019 black. The shoe was prepared with colored chalk spray on the areas away from the focused stud. A customized add-in to the TrakTester [3] was built to fix the transparent stone above a hole through which the contact area could be filmed with the help of a 45-degree mirror. A Sony 4K HDR FDR-AX700 camcorder [5] was used for the experiment. The TrakTester [3] was then used to load the shoe with a vertical force of -62N ± 3N and move the stone in the x-direction from 0 to 1mm and from 1mm to -5mm (See Fig. 1.a for the experimental setup). In order to correct the image distortion caused

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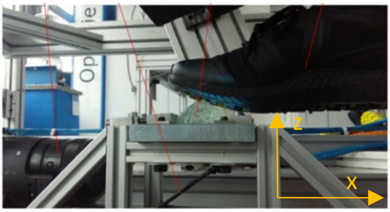
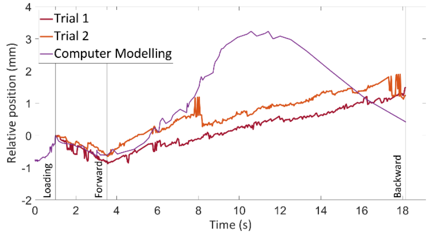
by the light diffraction on the transparent stone, a self-made software was developed.



(a)



(b)

Fig. c: (a) Experiment setup installed in the TrakTester; (b) Relative movement of the tip of the stud in relation to the shoe sole postition

Information about the position of reference points on the stud and the change of the contact area during the motion sequence is then extracted with the help of image processing methods. (See Fig. 1.b) The TrakTester and the image processing method were validated separately. A FEM simulation was supposed to be used for the validation of the whole methodology but as shown in Fig. 1.b there are differences between the behaviour of the stud in the experiment and in the computer modelling. The small asperities of the stone surface make the interface hard to modelize. Further works should focus on the reliability of this method.

Conclusion: This work aims in sharing a way to study the properties of the shoe - surface interaction for the case of a stony ground and by means of other sensory inputs, like forces measured on the shoe or displacement of the shoe, it is possible to obtain other related results. It also produces a video of the contact area during the experiment and offers a customizable workflow to adapt the experiment to different situations or to compare different stud materials and configuations.

[1] ITRA, “Trail-Running-Infographics.,” *Itra.Run*. p. en ligne, 2020. Available online: https://itra.run/documents/Infographics/FR-ITRA-Trail-Running-Infographics-2020.pdf.

[2] D. T. Nguyen, S. Ramakrishna, C. Fretigny, N. D. Spencer, Y. Le Chenadec, and A. Chateauminois, “Friction of rubber with surfaces patterned with rigid spherical asperities,” *Tribol. Lett.*, vol. 49, no. 1, pp. 135–144, 2013, doi: 10.1007/s11249-012-0052-3.

[3] T. Grund, V. Senner, and K. Grube, “Development of a test device for testing soccer boots under gamerelevant highrisk loading conditions,” *Sport. Eng.*, vol. 10, no. 1, pp. 55–63, 2007, doi: 10.1007/bf02844202.

[4] “Epoxidharz 2K-700 Pro | Dipoxy Germany.” Available online: https://dipoxy.de/dipoxy-epoxidharz-2k-700-pro (accessed Aug. 13, 2021).

[5] “4K HDR Camcorder with Fast Hybrid AF | 4K Handycam FDR-AX700 | Sony UK.” Available online: https://www.sony.co.uk/electronics/handycam-camcorders/fdr-ax700 (accessed Aug. 16, 2021).

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