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**CYCLISTS' PHYSIOLOGICAL STRESS AND NETWORK PLANNING AND
EVALUATION**

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RESUMO

NUÑEZ, J. Y. M. **Estresse fisiológico dos ciclistas e planejamento e avaliação de redes cicloviárias**. 2018. Tese (Doutorado) - Escola de Engenharia de São Carlos da Universidade de São Paulo, 2018.

Os planejadores de transporte precisam avaliar as condições de estresse dos usuários em infraestruturas cicloviárias, uma vez que situações de alto estresse podem desencorajar o uso deste modo de transporte sustentável. Poucas pesquisas têm questionado se existe alguma relação entre esses fatores ambientais e a resposta emocional em termos de medidas objetivas do estresse. O objetivo deste trabalho é explorar a incorporação de sensores inteligentes no planejamento e avaliação da infraestrutura cicloviária. Essa nova abordagem é focada na perspectiva de monitorar parâmetros intrínsecos ao usuário, como as emoções. Nesta perspectiva, os indicadores dos níveis de estresse são feitos a partir da medição direta de respostas fisiológicas em ciclistas ao longo do percurso. Essa abordagem aproveita os recursos tecnológicos para extrair informações dos usuários e permitir o uso dessas informações de forma integrada para melhorar a infraestrutura dos ciclistas. Os dados foram coletados por meio de sensores de estresse, de ruído e acelerômetros incorporados a um *smartphone* e GPS. Inicialmente é apresentado o problema e como o projeto e avaliação das ciclovias tem sido abordada na literatura. A abordagem proposta permitiu identificar as contribuições mais relevantes e as lacunas de pesquisa, tais como, a falta de pesquisas baseadas em critérios de objetivos e a falta de pesquisas que envolvam o desenho e a avaliação de cenários de infraestrutura compartilhados com veículos automotores. Em seguida foi proposto um método objetivo de avaliação de infraestruturas cicloviárias, combinando a avaliação ambiental com medições de aceleração vertical, a fim de melhorar a coleta de dados e outros procedimentos necessários para avaliar os principais componentes das infraestruturas cicloviárias. Na sequência uma ferramenta para caracterizar o estresse de tráfego de ciclovias, denominada *Level of Traffic Stress* (LTS), foi validada com medidas fisiológicas no contexto urbano de uma cidade brasileira de porte médio. Observou-se que não há correlação e há pouca concordância entre esses parâmetros. Ressalta-se ainda que, mesmo ao incorporar informações de velocidade de tráfego à ferramenta LTS, não foi significativamente relacionado com estresse medido sob a perspectiva do ciclista. Por fim, foi investigada a influência do ruído, vibração, presença ou ausência de ciclovias e período do dia no estresse experimentado pelos ciclistas. Uma análise dos valores de p e dos intervalos de confiança das razões de chances mostraram, com um nível de confiança de 95%, que apenas o período do dia influenciou o estresse. Neste caso, as chances de ter estresse aumentaram em 24% na hora pico da tarde em comparação com a hora pico da manhã. Este estudo mostrou a viabilidade da avaliação do estresse em ciclistas por meio de um método de medida objetiva além da rápida identificação dos níveis críticos de estresse.

Palavras-chave: Planejamento de Transporte Cicloviário, Sensoriamento, Estresse, Ruído, Vibração, Infraestrutura cicloviária. Data mining

ABSTRACT

NUÑEZ, J. Y. M. **Cyclists' physiological stress and network planning and evaluation** 2018. Thesis (PhD) - Escola de Engenharia de São Carlos da Universidade de São Paulo, 2018.

Transportation planners need to assess users' stress conditions on cycling infrastructures given that highly stressful situations can discourage the use of this sustainable transport mode. Not many studies have addressed the relationships between these environmental factors and users' emotional responses in terms of objective measures of stress. The aim of this study is to explore a new approach for planning and evaluating cycling infrastructure, based on smart sensors. This new approach focuses on the perspective of monitoring parameters intrinsic to the user, such as emotions. In this perspective, the indicators of stress levels are made from directly measuring cyclists' physiological responses throughout the journey. This approach makes use of technological resources to extract information from users through sensors and imparts this information in an integrated way to improve infrastructures for cyclists. The data were collected using stress and noise sensors, accelerometers embedded in a smartphone and a GPS. Initially, the problem is posed and we discuss how the design and evaluation of cycle paths has been addressed in the literature. The proposed approach identifies the most relevant contributions and research gaps, such as the lack of research based on objective criteria and research that involves designing and evaluating infrastructure scenarios shared with motor vehicles. In the sequence, an objective method for assessing bicycle infrastructures combining environmental assessment with vertical acceleration measurements was proposed in order to improving data collection and other procedures required for assessing the main components of cycling infrastructures. Subsequently, a tool to characterize traffic stress of cycling routes, called the Level of Traffic Stress (LTS), was validated with physiological measures in the urban context of a medium-sized Brazilian city. It was observed that there is no correlation and little agreement between the parameters. It is also emphasized that even when incorporating information about the traffic speed to the LTS tool, it was not significantly related to stress from the perspective of the cyclist. In the final analysis the influence of noise, vibration, cycle paths and period of day on stress experienced by cyclists was investigated. An analysis of the p-values and odds ratio confidence intervals shows, with a 95% confidence level, that only the period of the day influenced stress, as confirmed by the data. In this case, the chances of having stress increased by 24% in the afternoon rush hour compared to the morning rush hour. This study showed the feasibility of stress assessment in cyclists using an objective measurement method, as well as quick identification of critical levels of stress.

Keywords: Cycling Transportation Planning, Sensoring, Stress, Noise, Vibration, Bicycle infrastructure, Data mining.

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