

Story of ESUM

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I am bit perplexed how I go ahead and spell out the acronym "ESUM¹." It is because the acronym "ESUM" is no longer an acronym, it instead becomes a noun, a concept, and the concept that is necessary for the cities and the urban development. I can say it with certainty since experience and perception of humans or the humanistic aspect in the fast-growing urbanism is long forgotten or being largely overlooked. I cannot confirm it worldwide, which is contradicting my previous statement but ESUM is was found relevant in Zurich, Switzerland and Weimer, Germany. Zurich continually ranks in top place in the world's most livable cities². This fact then eliminates my contradicting statement and support the necessity of ESUM, which deals with researching the question: what causes one's experience and perception to fluctuate in an urban environment. This question is vital for both developing and developed cities because it answers/ solution encompasses topics of environment/climate impact on humans, the built environment and urban spaces impact on humans. ESUM follows the following phases in its development to its current state:

ESUM begins with the proposal of a **Swiss National Science Foundation project at ETH Zurich**, Switzerland for measuring and finding trade-offs between energy and social potential of urban morphology. It then took shape as a research for answering the question: what urban environmental variables (weather conditions, traffic, architectural features) impact humans who experience the environment while walking and commuting in the cities wearing environmental and physiological sensors. Some of the experiment with participant were conducted in cities like Zurich, Weimar, Singapore, Melbourne, Shenzhen, and Hong Kong.

Complex as it seems the question as to how to investigate this relationship between the urban environment and its perception of humans, the **machine learning** emerge as a viable tool to reveal this mystery. Machine learning application also compels to bring with it the additional necessary tools like signal processing and data fusion techniques. In its entirety, data related to environment (weather sensor data) and human's experience (biofeedback sensor data) processed and fused together to generated a high-level dataset that was explored by the machine learning tools to revealed various relations³ between the environment and human's perception.

The question of whether to rely on a fixed threshold or to have a flexible threshold for determining the physiological arousal level during the signal processing was a major challenge. Although the fixed threshold gives an indicative arousal level, the **flexible threshold** looks more intuitive than using fixed thresholds since the different person may have different environmental conditions acceptability.

How much control do we have when we relate the human's perception with the only built environment? This question posed an additional challenge. While investigating this, weather condition needs to be eliminated. Thus, the **Virtual Reality** experiment helped in increasing abstraction level and helped in examining the direct impact of the built environment over the human's experience.

The latest **deep learning**, the so-called tool of industry 4.0, is the ultimate tool in investigating the further relation between visual features of the built environment on human's perception. It offers a direction that provides answers that are precise and with the accord of visual perception. It begins with processing images, extracting features of the built environment, clustering them in different groups, and investigating the subjective (rating votes) and objective (biofeedback) scores. Further, feeding them (high-level information in the form of cluster images) to a convolutional neural network for extrapolating a street scale experiment to city scale experiment and one city to another city. Additionally, a **spatial statistics** analysis help to investigate whether similar built environment have identical impact on the humans perception.

¹ <http://esum.arch.ethz.ch/>

² https://www.swissinfo.ch/eng/society/living-the-good-life_zurich-and-geneva-among-top-five-european-cities/44319586

³ <http://esum.arch.ethz.ch/knowledge>