Summer overheating mitigation in urban areas of rich cultural heritage: The Smart and Urban Tree Approach

Artificial structures as performance-optimizing supplement for historic cities.

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Introduction

This contribution illustrates the idea, the methodological approach and prelminary results of a recent research and developement project adressing overheating and climate change mitigation in historic city centers. Such city structures represent regularly highly-densified agglomerations, and thus can be per se considered as fortunate in view of ecological footprint of its dwellers. Instances of the performance advantages of urban structures encompass the reduced necessity of individual motorization as well as the low carbon footprint of buildings due to their long existance (100 years and more). However, such city structures are potentially prone to overheating risk and strenous impacts of climate change. This is due to the high specific heat capacity of used materials (brick buildings), the competition for different usages of the interstitial public spaces, such as roads, and the lack of greenary. Moreover, large scale heat sources, such as A/C-split units lead to uncomfortable conditions during the hot season. Trees and greenary are considered to be the logical choice in reducing the negative impact of urban heat islands. Sadly, trees can not be applied everywhere, as not only above surface there is limited space, but also below terrain very often sub-soil lines for water, gas, and energy supply, as well as sewerage can be found. Moreover, sub-terrain public transport requires also space below the street surfaces. These obstacles often hinder the implementation of natural trees into the cityscape. Moreover, given the urgency of city cooling in the recent climate change scenarios, trees would require very often too long to have a strong impact on the local microclimate. This is where the idea of smart and urban trees would allow to supplement greenary and shading whereever natural trees are not applicable or not feasible to grow. In this

paper, we discuss the relation of such artificial super structures (that we name smart and urban trees) in contrast to the cultural heritage cityscape via a demonstration project conducted together with graduate students of architecture at the TU Wien, Vienna Austria.

Necessity for and requirements of large scale artificial shading structures

Examples for large scale artificial shadind structures, such as the metropl parasol in Sevilla (Metropol Parasol 2022) or the supertrees of Singapure (Supertrees 2022), widely have an impact as architectural icons or sense-of-wonder-attractions, rather than as useful structures for the city dwellers and street occupants. However, they indicate the critical necessity for urban shading. In our approach for Smart and urban trees – namely the generation of useful large scale structures that can be placed whereever trees are not possible – we address the street and place structures of the city centeres. Beside their shading functionality, the structures need to offer a wide array of additional benefits and amenities to the city dwellers, need to avoid any discomfort and harm to dwellers, city services and occupants, and require a small footprint both in view of ecological impact as well as for structural foundation. The latter needs to be mentioned, as the smart and urban trees should be applicable wherever there is no space and possibility for natural greening with trees. The functions of the smart and urban trees should encompass: (i) shading; (ii) active cooling (evaporation of plants/greenary, water misting, ...) (iii) active energy generation (e.g. via Photvoltaics on the shading planes), (iv) artificial lighting (street lights), (v) provision of electricity, water, or other amenities for passing by people, (vi) identification (authentic location, effect lighting, orientation), (vii) added benefits such as noise reduction, rain protection, ...; The limiting requirements for such structures encompass: (i) no reduction in life quality for neigbours (e.g. reduction of daylight in critical seasons, loss of privacy, loss of urban character of the street), (ii) no reduction in reachability for urban and emergency services (e.g. postal services, waste collection, firefighters); (iii) no reduction in the perception of the cultural-heritage aspects of the streets / roads, compare relevant monument's protection documents (e.g. Charta of Venice 1964); (iv) easy and durable construction, resistance against vandalism, easy and inexpensive maintenance; The following table 1 compares aspects of natural trees, smart and urban trees, and no action/intervention at all regarding different aspects:

Case study: Designs of smart and urban trees for a sensitive urban context in the City of Vienna

In summerterm 2022, the urban area "Siebensternviertel" of the 7th Viennese city district has been subjected to a design studio focussing on the generation of smart-and-urba-tree structures. Some of the results are depicted in Figure 1 (the envisioned structures in front of the street facades in views) and 2 (some impressions). The impact assessment of both of the energy / lighting / shading and the cultural heritage aspects of the principal idea are currently work in progress. Thereby state-of-the-art technologies, such as numeric simulation tools are employed, as well as stakeholder interviews with experts of different backgrounds. Via this approach, a widely holistic view on such urban canopy structures seems to be reachable that, amongst other aspects, is in a vital relation to the built heritage of European cities.

Table 1. Comparison of different aspects of trees, smart-and-urban-trees and a "no-intervention at all" scenatio

Aspect	Natural Tree	Smart & Urban Tree	No intervention
Greenary (Integration of greenery)	+	+/-	-
Shadow casting	+	+	-
Seasonal shading	+	+/-	-
cooling effect by shading and evaporation/mist	+	+	-
(Day)Light / (Day)Light control	+/-	+	-
Inhibition of free air movement	-	-	+
„Rain protection" / roofing effect	+/-	+/-	-
Additional functions can be integrated (light, spray, E-charge, …)	-	+	-
Active electricity/Energy production (PV)	-	+	-
(Neigbor/Occupant)Acceptance	+	?	
Improvement of the street space	+	+	-
Seasonal use/usages of the street space	+/-	+	+
Implementation is simple and proven	+	-	n.a.
Can be implemented quickly and immediate	-	+	n.a.
Root space / foundation freely configurable	-	+	n.a.
Water not required for "maintenance"	-	+/-	n.a.
Costs (construction and maintenance)	+/-	-	n.a.
Care / maintenance	+/-	+/-	n.a.
Pollution of the soil	+/-	+/-	n.a.
Pollution of the construction (e.g. birds)	+	-	n.a.
Not-affected / affected building regulations	+	-	n.a.
Fire brigade access	+/-	+/-	+
Parking lot displacement	+/-	+/-	+
Unsealing	+	+	-
CO_2 binding with a metal construction SUT	+	-	-
CO_2 binding with a wooden construction SUT	+	+/-	-
O2 generation	+	-	-
Noise cancellaton	+	+	-
Dust binding	+	+	-
"Residue-free" / simple dismantling	+	+/-	
Impact on cultural heritage	+	+/-	+

Figure 1: Different designs of smart and urban tree structures (as views)

Figure 2: Different designs of smart and urban tree structures as models/renderings

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No conflicts of interest.

Author Contributions

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Project Administration: UP, MW
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Writing – original draft: UP, MW
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