AUTOMATED DRIVING: DRIVING URBAN DEVELOPMENT?

AN INTEGRATED RESEARCH-BY-DESIGN COMPUTATIONAL MODELLING APPROACH IN URBAN PLANNING PROBLEMS

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27/10/207

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P5 FINAL PRESENTATION

MSC ARCHITECTURE, URBANISM AND BUILDINGS SCIENCES
INTEGRATED APPROACH

AUTOMATED DRIVING
INTRODUCTION TO VEHICLE AUTOMATION

[Diagram showing the relationship between automation, connectivity, autonomous vehicles, automated vehicles, connected vehicles, Google car, Tesla autopilot, CACC, Truck platooning, ACC, Dynamic route information, and under development areas.]
DEGREES OF AUTOMATION

- no automation
- partial automation
- conditional automation
- full automation
APPLICATIONS OF AUTOMATED DRIVING

- vehicle-to-vehicle (V2V)
- vehicle-to-infrastructure (V2I)
- vehicle-to-system (V2C/V2X)
- vehicle-to-other road users (V2P)
- new user groups
- empty ride allocation
- platooning
- intersection management
- dynamic responsive transit
- last-mile solutions
- public transport in low demand areas
- network wide traffic coordination

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TECHNOLOGY

AUTOMOBILE AUTOMATION

AUTONOMOUS DRIVING

CONNECTIVITY

APPLICATIONS

AUTOPILOT SYSTEMS

SHARED FLEETS

FIRST & LAST MILE SOLUTIONS

TRAVEL DEMAND/BEHAVIOUR

TRAVEL COST FACTORS

INFRA CAPACITY & REQUIREMENTS

IMPLICATIONS

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A TECHNOLOGY IN TRANSITION

AUTOMOTIVE INDUSTRY
- Five.ai
- Nissan
- Ford

INSTITUTIONS
- ERTRAC
- Institute of Customer Experience
- Rijkswaterstaat

CONSULTANTS
- Morgan Stanley
- Roland Berger
- Canalys
- BCG
- KPMG
- IHS
- McKinsey

SCHOLARS
- Cummings
- Levin & Boyles
- Litman
- Chapin
- Shladover

• prediction of availability
○ prediction of full market penetration

3 SAE level (if applicable)
UNCERTAINTY AROUND THE IMPLICATIONS

Literature findings of expected change of various aspects of mobility related to vehicle automation

- Value of time
- Road capacity urban
- Road capacity regional road
- Road capacity highway
- Parking
- Intersection
- Induced travel demand
- Car sharing

Change [%]

-100% 0% 100% 200% 300% 400%

Type
- Scenario/assumption
- Simulation

Penetration rate
- 25
- 50
- 75
- 100
AN INTEGRATED APPROACH TO URBAN PLANNING PROBLEMS

[Image: Courtesy of BIG]
TRANSPORT SYSTEM

INTEGRATION

ACTIVITIES

LAND USE
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COMPLEX URBAN PLANNING PROBLEMS
A DIFFERENT PARADIGM FOR CITIES

photo: Heleen Klop, constrast and colour adjusted by author
How can an integrated engineering-based and design-based research lead to better understanding of urban planning problems and what are the consequences of an integrated approach for the research process?
<table>
<thead>
<tr>
<th>Fundaments</th>
<th>Engineering-based research</th>
<th>Design-based research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals</td>
<td>Derive general rules</td>
<td>Elaborate on values and have impact</td>
</tr>
<tr>
<td></td>
<td>Objective interpretation</td>
<td>Individual signature</td>
</tr>
<tr>
<td></td>
<td>Reproducible research</td>
<td>Creative approach/outcome</td>
</tr>
<tr>
<td>Domain</td>
<td>Scientific</td>
<td>Humanities and arts</td>
</tr>
<tr>
<td>Reported process</td>
<td>Sequential</td>
<td>Iterative</td>
</tr>
<tr>
<td>Models</td>
<td>Mathematical formulation</td>
<td>Visual representations of context</td>
</tr>
<tr>
<td>Variables</td>
<td>Quantitative</td>
<td>Qualitative</td>
</tr>
<tr>
<td>Scope</td>
<td>Narrowed down</td>
<td>Holistic</td>
</tr>
</tbody>
</table>

Figure 2-4 provides a graphical representation of how an integrated research process can be shaped. This scheme shows how engineering thinking can be integrated within design thinking. The reason for this order and not the other way around is that urban planning problems always comprise many variables and should therefore be considered from a holistic perspective. It is important that the problem statement supports this. With the help of a computerised (in this case urban) model, the complex and non-recurrent factors are evaluated. When this model generates results, these allow for value-based interpretation and new design principles. These can then in turn be re-evaluated with the urban model, eventually leading to better understanding of the urban planning problem and better policy and design solutions.

Figure 2-4: Graphical representation of an integrated design and engineering based research process (for legend see Figure 2-3)

From this elaboration, the potential of an integrated method reveals. Yet, there are some challenges within an integrated methodology. These challenges are hard to tackle and might provide for an explanation of why the cultural divide sustains. The primary challenge related to the formalisation of the method emerges from the need of compatible steps. Within an engineering-based research, the system is explicitly defined. To establish a bridge within other research steps that are more characterised by design-thinking the compatibility between the research steps is an issue of concern. Model outcomes do not often directly...
A COMMON GOAL

In research to urban planning problems...

...The goal is not to raise an artefact
...The goal is to fill a knowledge gap

How can urban development be steered towards a desired goal in the future through interventions?
AN INTEGRATED APPROACH ASKS FOR A DIFFERENT LOOK AT CITIES
spatial interaction
random utility/discrete-choice
microsimulation

PATH OF DEVELOPMENT

1960

gravity models
Lowry

1970

spatial interaction
models
ITLUP/DRAM/EMPAL

1980

input-output model
La Porte

1990

urban economic bid-rent
typeory
Alonso

2000

agg. equilibrium
discrete choice
MUSSA

2010

agg. dynamic
discrete choice
HUDS

microsimulation

GIS

spatial detailed rule-based
discrete choice
UrbanSim

big data

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RESPONSE TO EMERGENT PATTERNS

INTERACTION BETWEEN AGENTS

RESEARCH IDENTIFY DEVELOPMENTS AND CHALLENGES

URBAN DEVELOPMENT SYSTEM

URBAN DEVELOPMENT MODEL

EMERGING PATTERNS

RESPONSE TO EMERGENT PATTERNS

DESIGN POLICIES AND SPATIAL INTERVENTIONS

OTHER DECISION MAKERS AND DEVELOPMENTS

OBSERVATION

EXPERIMENT

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RESEARCH STRUCTURE

1. Scenario Development
   - Assumptions
   - AV Variables

2. Regional Design
   - Link Loads & Travel Behaviour

3. AV Transport Modelling
   - Accessibility Effects
   - Urban Space Potentials

5. Urban Model
   - Assessment & Evaluation

6. Urban Transformation Strategy

MODELLING

RESEARCH-BY-DESIGN

AV Predictions

AV Literature

Transport System Scenarios

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SCENARIO APPROACH

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PRESENT FUTURE

POSITIVE

NEUTRAL

NEGATIVE

SCENARIO APPROACH

base

transformation

growth

constraint

decline
transformation
growth
constraint
decline
ACCESSIBILITY AND TRAVEL EFFECTS
How to model self-driving cars?
- Value of time changes
- Route factors
- OD-matrix mutation
- Infrastructure capacity
Trip distribution is determined within VRU using a simultaneous gravity model. Therefore, there is no destination utility data available within the model. A consequence of this is that accessibility cannot be expressed by means of utility-based indicator. Instead, a potential accessibility measure is used as indicator to examine accessibility changes:

\[ A_i = \sum_{j=1}^{n} D_j \cdot F_m(Z_{ijm}) \]

\[ F_m(Z_{ijm}) = \alpha_m \cdot \exp(\beta_m \cdot \ln^2(Z_{ijm} + 1)) \]
BASE YEAR ACCESSIBILITY
ACCESSIBILITY CHANGES
relative change in accessibility of VRU zones by scenario (2500 zones)
CONGESTION

transformation
CONGESTION

constraint
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NEIGHBOURHOOD TYPOLOGIES

LEGEND
- centre-urban plus
- centre-urban
- centre-small-urban
- small-urban
- urban pre-war
- urban post-war compact
- urban post-war ground-level
- green-urban
- green-small-urban
- centre-village
- village
- rural
- work
- other/unknown
TRANSFORMATION POTENTIAL

[Image of urban area]

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SMALL-URBAN (HWM7)

BASE

TRANSFORMATION
SUPPLY/DEMAND

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move-or-stay

calculate vacant dwellings

supply and demand

final location choice

percente of vacant dwellings
neighbourhood type
accessibility
housing price (woz)
neighbourhood type
accessibility
income
household density
land-use

percentage of vacant dwellings

neighbourhood type
accessibility
housing price (woz)
neighbourhood type
accessibility
income
household density
land-use

move-or-stay

calculate vacant dwellings

supply and demand

final location choice

start

ITERATION
ITERATION
ITERATION
ITERATION
UPDATE
HOUSING VALUES
MANAGE VACANT DWELLINGS

MOVE-OR-STAY

TARGET LOCATION CHOICE

ITERATION

done?

SUPPLY AND DEMAND

FINAL LOCATION CHOICE

end

percentage vacant dwellings
neighbourhood type
accessibility
housing price (woz)
neighbourhood type
accessibility
income
household density
land-use

housing stock
household population

HOUSES

NEIGHBOURHOOD TYPE
ENVIRONMENT
HOUSING PRICE
ACCESSIBILITY
DISTANCE FROM ORIGIN
Het aantal vacante woningen is het verschil tussen het totale aantal woningen en het aantal binnenlandse migratie/verhuizingen; de internationale migratie per zone is al bepaald in de vacante woningen. Dit aantal beschikbare woningen heeft uitsluitend betrekking op het mogelijke inkomende aantal verhuizingen in een zone wordt beperkt door het aantal...

Vergelijking 5-3:

\[ \text{VH} = \text{H} - \text{P} \]

waarbij:

- \( \text{VH} \) = saldo verhuizende huishoudens
- \( \text{H} \) = aantal huishoudens
- \( \text{P} \) = aantal woningen
- \( \tau \) = het deel van het nut dat niet observeerbaar en/of kwantificeerbaar is

Uit de nutsfunctie wordt de verhuiskans bepaald met een binomiaal logit model zoals in...

Locatiekeuze:

De locatiekeuzes van huishoudens wordt net als de verhuiswens met een logit model...

Tabel 5-3: Overzicht variabelen gebruikt in het move/stay-model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>move-or-stay</td>
<td>Options for moving or staying</td>
</tr>
<tr>
<td>target location</td>
<td>Choice of target location</td>
</tr>
<tr>
<td>iteration done?</td>
<td>Iteration done?</td>
</tr>
<tr>
<td>final location</td>
<td>Final location</td>
</tr>
<tr>
<td>end</td>
<td>End of process</td>
</tr>
</tbody>
</table>

Iterative process:

1. Start
2. Move-or-stay
3. Calculate vacant dwellings
4. Supply and demand
5. Target location choice
6. Iteration done?
   - Yes: Final location choice
   - No: Iterate
7. End

Variables:

- percentage vacant dwellings
- neighbourhood type
- accessibility
- housing price (woz)
- location choice
- income
- household density
- land-use

Factors:

- housing stock
- household population

zones, environment, housing price, accessibility
CHANGE IN ATTRACTIVITY FOR HOUSING

TRANSFORMATION

CONSTRAINT

GROWTH

DECLINE

LEGEND

< -20%
-20% - -15%
-15% - -10%
-10% - -5%
-5% - 0%
0% - +5%
+5% - +10%
+10% - +15%
+15% - +20%
> +20%
MICROSCOPIC BEHAVIOUR

EMERGENT PATTERN

PHYSICAL MANIFESTATION

RESULTS

CONCLUSION
THE ASSIGNMENTS FOR AUTOMATED DRIVING
THE ASSIGNMENTS FOR AUTOMATED DRIVING
nodes facilitate clustering of flows

are an opportunity for urban development

can provide for future automated driving developments
INTERVENTIONS
INTERVENTIONS
INTERVENTIONS
RECOMMENDATIONS