A FRESH LOOK
AT THE OBJECT-FIELD
DICHTOMY

MIKE WORBOYS
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Models of the world

NOT the world itself
TIMELESS

Object

Field

Entities

functional

Attributes

Locations

Locations

Attributes
Mathematical structures
< Set, Op, ...., Rel, .... >

Entities
Attributes
Locations
Mathematical structures
\[ \langle \text{Set}, \text{Op}, \ldots, \text{Rel}, \ldots \rangle \]

Entities \( E \)

Attributes \( A \)

Locations \( \Rightarrow \text{Spatial} \ S \)

\text{Spatiotemporal} \ \text{SXT}
$S \left\{ \begin{array}{l}
R \times R \\
N \times N \\
P(R \times R) \\
\text{Graphs}
\end{array} \right. \quad R^3 \ldots \ldots$
Goodchild's geo-atom

\[ <x, Z, z(x)> \]

point in space-time

property

value of property at x
ADDING TIME

Object

E

Field

S x T → A
But now

\[ E = \text{Continuants} \cup \text{Occurrants} \]

\text{Swap and Span}
Event $\Rightarrow$ State change
This process is **deterministic**, as there is at most one transition \((q, a, q')\), for each pair \((q, a)\).

**Process notation:**

\[
\begin{align*}
Q_0 &= aR \\
R &= bS + cQ_0 \\
S &= cQ_0
\end{align*}
\]
This process is **nondeterministic**, as there is more than one transition $a$ with start state $q_0$.

**Process notation:**

$$Q_0 == aR + aT = a(R+T)$$

$$R == bS + cQ_0$$

$$S == cQ_0$$

$$T == cQ_0$$
Process model

These processes communicate via input action $a$ and output action $\overline{a}$. The combined process is $Q_0 \mid T_0$

Process notation:

- $Q_0 = aR$
- $R = bS + cQ_0$
- $S = cQ_0$
- $T_0 = aU$
- $U = dT_0$

$Q_0 \mid T_0$

$U \mid R$

$U = dT_0$
Fourway stop processes

\[ X = \sum_i a_i X_i \]

\[ X_i = \overline{b}_i X + \sum_{j \neq i} a_j X_{ij} \]

\[ X_{ij} = \overline{b}_i X_j + \sum_{k \neq i,j} a_k X_{ijk} \]

\[ X_{ijk} = \overline{b}_i X_{jk} + \sum_{l \neq i,j,k} a_l X_{ijkl} \]

\[ X_{ijkl} = \overline{b}_i X_{jkl} \]
Leonhard Euler
1707 - 1783

Joseph-Louis Lagrange
1736 - 1813
Euler

$S \times T \rightarrow V$

Lagrange

$E \times T \rightarrow V$

includes 5
Euler: 
\[ S \rightarrow (T \rightarrow V) \]  
\[ T \rightarrow (S \rightarrow V) \]  
\{ PURE FIELD \}

Lagrange: 
\[ T \rightarrow (E \rightarrow V^*) \]  
\[ E \rightarrow (T \rightarrow V^*) \]  
\{ MIXED \}  
\{ PURE OBJECT \}
EULER

$S \times T \rightarrow V$

$S \rightarrow (T \rightarrow V)$

$T \rightarrow (S \rightarrow V)$

Time Series

Snapshots of spatial patterns
LAGRANGE \[ E \times T \rightarrow V \]

\[ E \rightarrow (T \rightarrow V) \]

\[ T \rightarrow (E \rightarrow V) \]

trajectories

snapshots of entity patterns
Euler: \[ S \rightarrow (T \rightarrow V) \] \[ T \rightarrow (S \rightarrow V) \] - Pure Field

Lagrange: \[ T \rightarrow (E \rightarrow V^*) \] - Mixed
[\[ E \rightarrow (T \rightarrow V^*) \] - Pure Object]
CASE STUDY

PEDESTRIAN MOVEMENT
Eulerian approach

\[ S \rightarrow \text{position (pt., roadseg., area)} \]

\[ T \rightarrow \text{linear time} \]

\[ V \rightarrow \# \text{people, flow velocity, congestion coeff.} \]
Figure 32 Pedestrian Per Hour (PPH) during the AM Peak Hour (0600 hours - 0800 hours)
Fig. 1 Schematic illustration of the pedestrian channel flow from the entrance, through a bottleneck, and to the exit. The widths of the left and right parts are $W_1$ and $W_2$. The length is $L$.

Takashi Nagatani

**Dynamical transition and scaling in a mean-field model of pedestrian flow at a bottleneck**


http://dx.doi.org/10.1016/S0378-4371(01)00366-1
Flow equation example

At point $(x, y)$, the conservation of pedestrians implies:

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x} (\rho u) + \frac{\partial}{\partial y} (\rho v) = 0$$
Lagrangian approach

E  pedestrians

V*  position

other attributes
  e.g. velocity, gender, type

T  linear time
Properties
- S-length
- T-length
- Circularity
- Sinuosity
- T-variability

Binary relations
- Equality
- Path equality
- Similarity
- Meet
- Inclusion
- Leading
Figure 2: Hausdorff vs. Fréchet distance
Figure 1  Classification of movement patterns.
LAGRANGE \leftrightarrow \text{?} \rightarrow \text{EULER}
Euler: \[
\begin{align*}
S & \rightarrow (T \rightarrow V) \\
T & \rightarrow (S \rightarrow V)
\end{align*}
\] - Pure Field

Lagrange: \[
\begin{align*}
T & \rightarrow (E \rightarrow V^*) \\
E & \rightarrow (T \rightarrow V^*)
\end{align*}
\] - Mixed - Pure Object
EUROBASKET 2015 2ND QR
ITALY v SWITZERLAND
THANK YOU!