Insurance Beyond Insurance

Cat Bonds and Index based insurance
in the perspective of actuaries

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Agenda

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2) Cat Bonds (Index based)

3) The role of IT: Big Data, Blockchain and Smart Contracts

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Motivation and goal

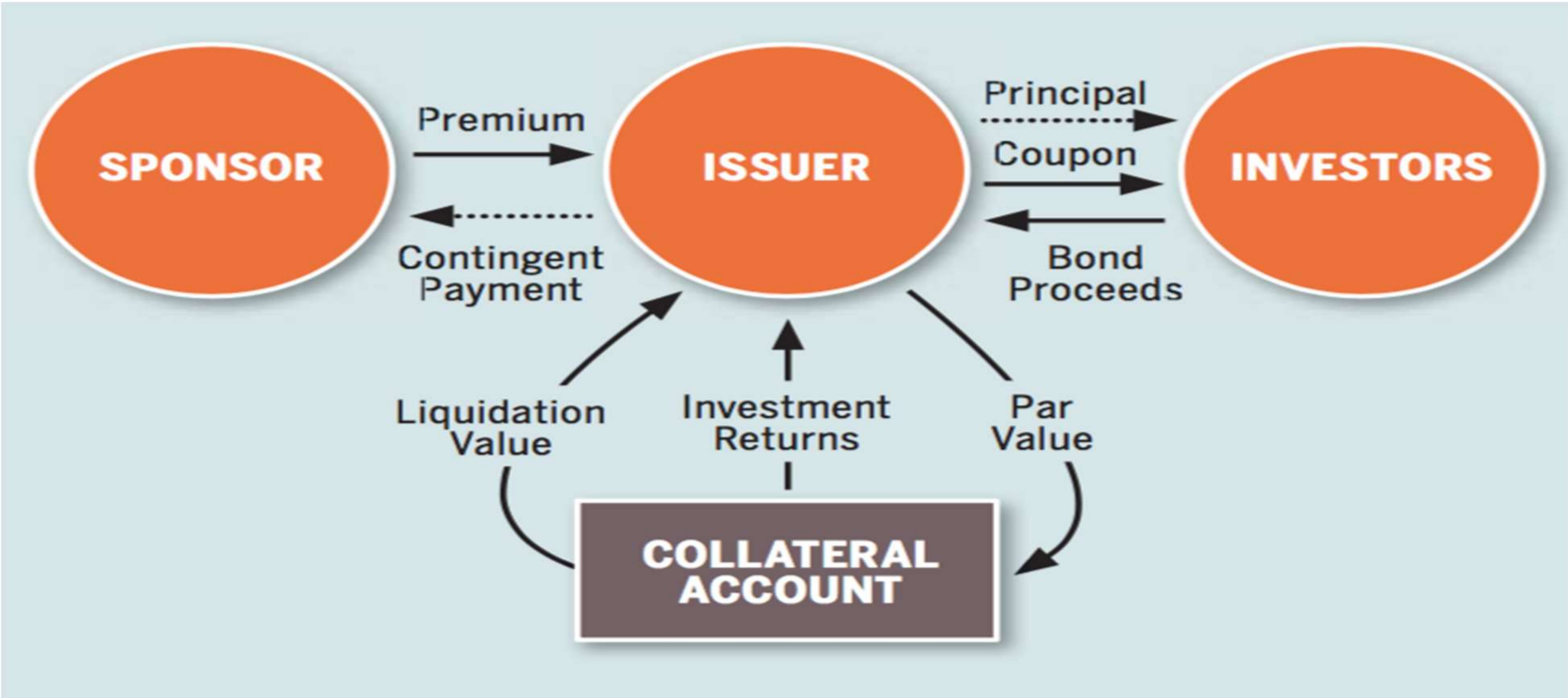
Among the set of Cat-risks, **climate change** provides **increasing levels of Cat-events** (storms, hurricanes, wind, floods, …).

Cat-risks ask for an **insurance coverage for huge amounts of damages** and this need **intervention of financial markets, using Cat bonds**, more proper than the classic insurance-reinsurance market.

IT offers a solid basis for registering **big databases related to these risk phenomena** (e.g. rainfall or waterbombs in certain areas, wind speed, hurricanes ratings) which can be used **for determining the insurance contract cash flows (Index based insurance)** without considering the effective level of damages.

Cat bonds

The cash flows scheme of a Cat Bond.



Cat bonds (Index based)

Two types:

1) **Indemnity based** (as for example ones issued by Generali insurance group against wind in Europe) which provide **refunding if the total damage will exceeds a fixed amount** (estimation would take very long time in some cases)

2) **Index based**: provide refunding **if an index (rainfall, river level, wind speed, …) will exceeds a fixed level**

The **advantages of Index based** refunding are:
- **transparency** (for all the agents)
- **quickness** (which can be crucial for the damaged units, stopping further indebtedness)

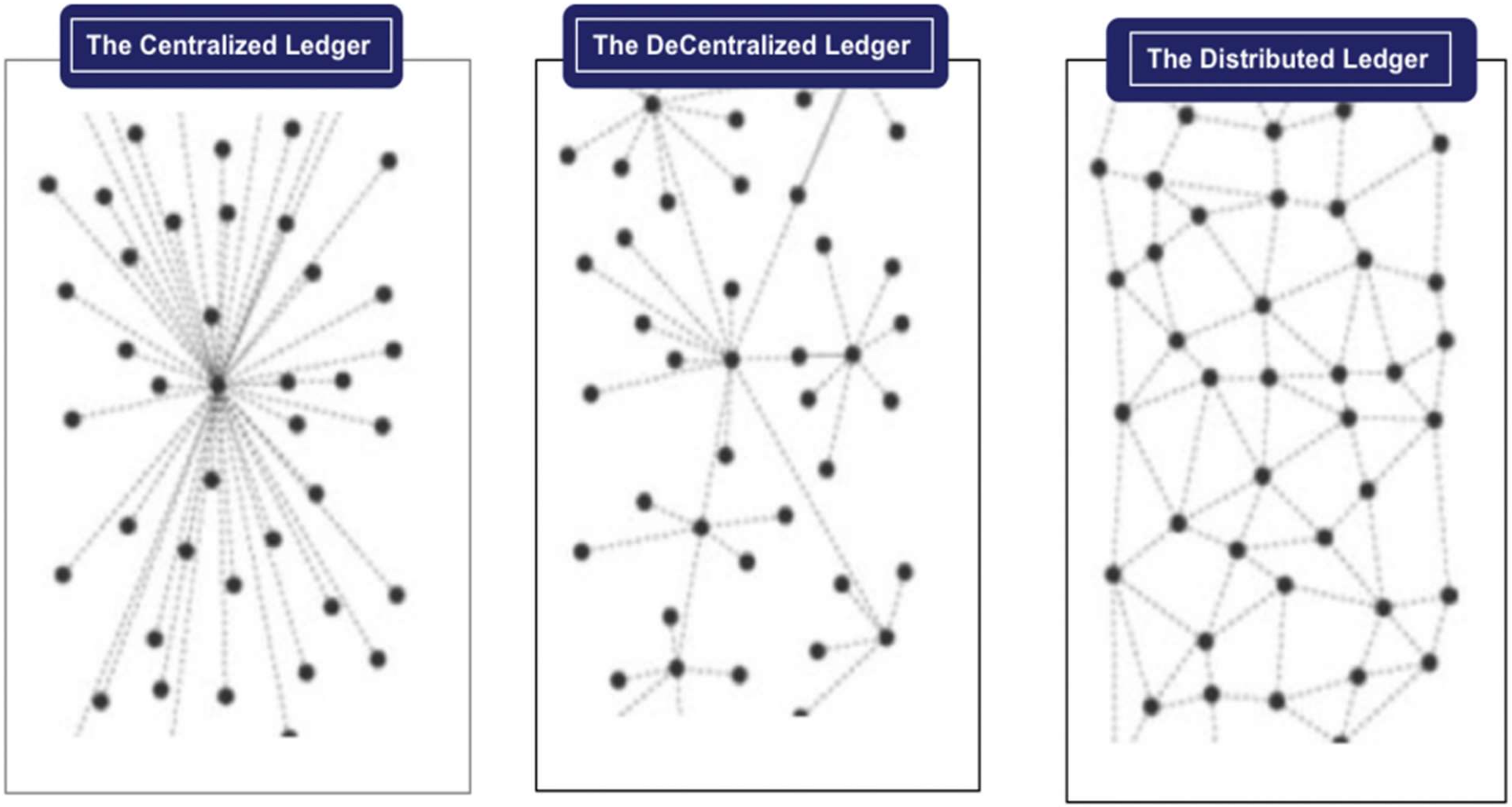
The role of IT:
big data, blockchain, smart contracts

For some Cat-events related phenomena we have huge databases (even big data): for example rainfall in fixed areas.

We may be interested in a **dynamic assessment of risk**, e.g. caused by trends in the historical series of climate phenomena (climate change), which could **provide effects on the cost of insurance**, making the premium increasing or decreasing, in a sort of **smart contracting approach**.

Blockchain should be the «natural» driver of such process: certification of the data and the tool for implementing smart contracts.

Blockchain as IT certifier



Resilience approach for hydrogeological risk

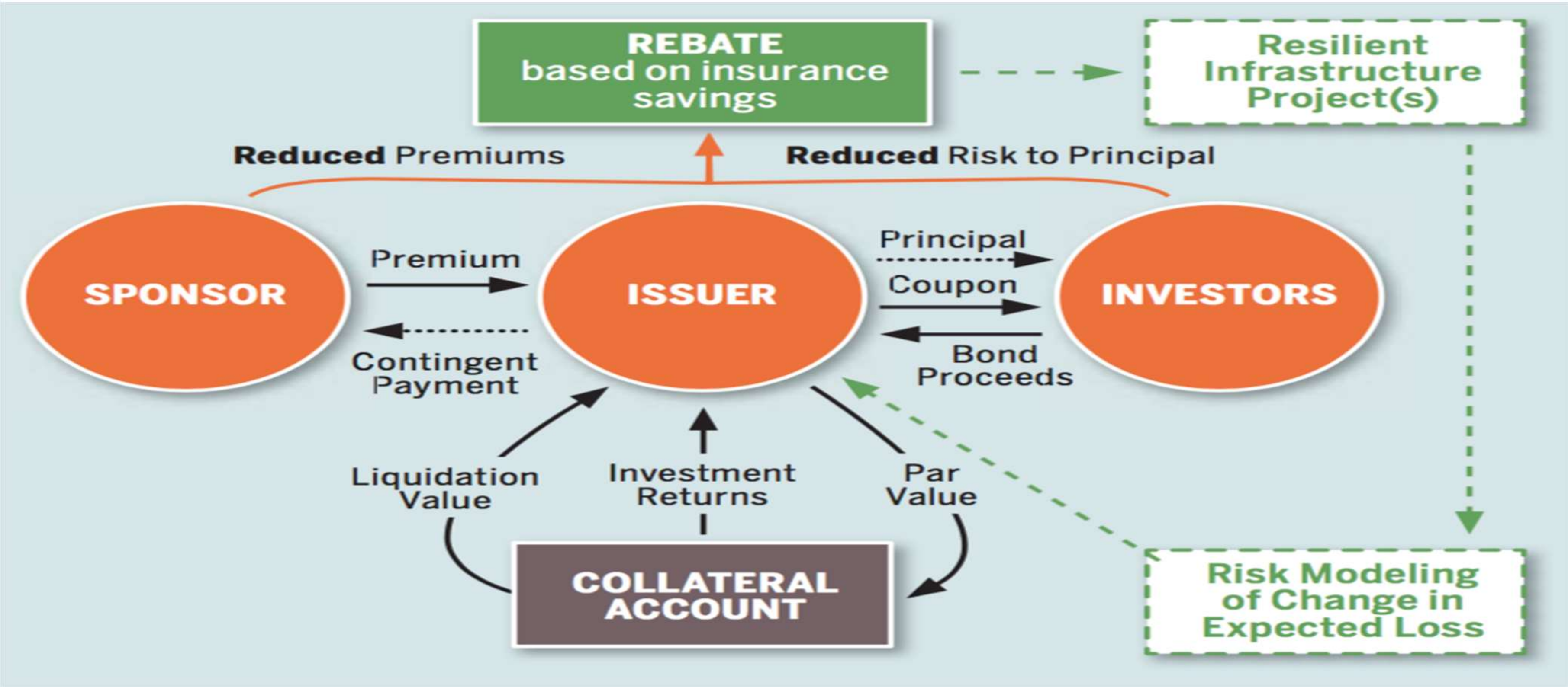
Public (local) administrations are responsable for restoring damages (public goods, public services) created by Cat-events.

Facing some Cat-risks, e.g. hydrogeological, **a more resilient approach respect to one implied by standard insurance refunding** style can be adopted: adding to insurance premium **a financing plan for mitigative infrastructures**, which **progressively reduce the original risk**.

The new financial tools underlying this approach are the so called **Resilience bonds**.

Resilience Bond

The cash flows scheme of a Resilience bond.



Resilience approach for hydrogeological risk

Not only trends in climate phenomena, but even the progressive building of mitigative infrastructures can affect the risk exposure: **an index** (certificated using blockchain) **of the level reached by the infrastructures already built could progressively reduce insurance premium**.

The goal could be **to establish a break even point**, such that if we consider **longer time horizons, we have a convenience in adopting the resilience strategy respect to the standard insurance one** (see Vannucci et al. (2021), Climate change management: a resilience strategy for flood risk using Blockchain tools; Decisions in Economic and Finance, pp. 1-14).

Quantitative analysis comparing standard insurance and resilience strategy

Historical series of hydrogeological damages paid by the p.a. (expectations for following years could be even due to climate change risk)

X yearly payment r.v. (time unit: 1 year) with distribution ***f(X)***, with moments $\mathbf{E}[X^r]$, ***r=1, 2, …*** (expected value, volatility, …)

“Standard insurance” scheme:

yearly constant premium ***P*** (or increasing in case of a trend due to climate change risk), based on r.v. distribution

Assume $P = g(f(X))$

(for example $g(f(X)) = E[X] + \lambda$ or $E[X]+\alpha\sigma[X]$, with $\lambda, \alpha>0$, fair premium with a charge for risk aversion).

Quantitative analysis comparing standard insurance and resilience strategy

Assume a mitigative infrastructure with cost $\boldsymbol{C}$ and a completion time $\boldsymbol{n}$, such that the expected yearly damage for following years (after time $\boldsymbol{n}$) is $\boldsymbol{X_R}$

$$E[X_R] = E[X] - d$$

where $d > 0$ is risk reduction, which must be assessed by engineering expertise, from which the insurance premium with the same function g, is

$$g(f(X_R)) = P_R < P$$

The assessment of risk reduction $\boldsymbol{d}$ could be an hard task, since it cannot be evaluated using historical series of damages (the mitigative infrastructure did not exist before).

Quantitative analysis comparing standard insurance and resilience strategy

Resilience strategy: for ***n*** years, insurance + financing mitigative infrastructures with cost ***C***.

Given ***i*** the rate available into standard financial markets, ***q*** is the ***n***-years installment for financing ***C***, that is

$$C = p.v.\ (q, n)$$

So the present value of the total cost for the first ***n*** years with a resilience strategy is

$$p.v.\ (P + q, n)$$

higher than

p.v. (P, n), total cost for “standard insurance”.

Quantitative analysis comparing standard insurance and resilience strategy

Consider a time horizon of ***m*** additional years (after ***n***): we have to compare the present values of the costs of the two strategies over ***n+m*** years

Standard insurance: ***p.v. (P, n+m)***

Resilience strategy: ***p.v.*** $(P + q, n) + (1+ i)^n$ ***p.v.*** (P_R, m)

in order to decide if a resilience approach is convenient.

We can obtain ***m**** as the minimum ***m*** such that the resilience strategy becomes convenient for each ***m>m****.

m* is the break-even point between standard insurance and resilient approach.

Quantitative analysis comparing standard insurance and resilience strategy

Numerical example, standard parametrization
$\mu = 1$, $\sigma = 2$, $d = 0.1$, $\alpha = 0.05$,

from which

$E[X] = 20.08$, $\sigma [X] = 90.01$, and $P = 24.58$

$E[X_R] = 12.42$, $\sigma[X_R] = 38.09$ and $P_R = 14.33$,

$C = 100$, $n = 5$, $i = 0.02$ from which $q = 21.21$ (it has to be payed for the planned n years of completion time).

Quantitative analysis comparing standard insurance and resilience strategy

Break-even point (m*) sensitivities respect to volatility (σ), infrastructure cost (C) and effect of the mitigation (d)

σ	m*
2	16
2.1	13
2,5	7
3	6

C	m*
100	16
110	17
150	21
200	26

d	m*
0.1	16
0.11	15
0.15	13
0.2	12

Resilience approach for hydrogeological risk

One crucial point for assessing the convenience is to define the cash-flows of the resilience strategy, **using an index based principle**, since we do not have any information of effective risk reduction in the future through mitigative infrastructures, and we can only assume an estimated index measure for this.

So we have a **dynamic risk assessment based on a double index**: one for **trends in climate phenomena** and another for **certificating the progress of the mitigative infrastructures**.

A Blockchain certification scheme should be a «natural» platform for this double index insurance-resilience scheme.

Smart contracts legal environment

Europe

European Parliament and Council, regulation n. 910/2014 for using data flows in real time (certification, automatization by smart contracts).

Italy

Art. 8-ter of DL 135.2018 converted into L.12/2019

AGID (Agency for Digital Italy), N. 116/2019, 10 may 2019, set up a Working Group for the provision of guidelines and technical standards for Blockchain and Smart Contract.

(implementing decrees in August 2019 have left much vagueness to the objet of the law)

Smart contracts legal environment

Crucial points for quantitative applications

From a quantitative actuarial point of view: the definition of multiperiodic or multiphase contracts, in order to admit changes in insurance premiums depending on indexes which define risk exposure dynamics.

From the principles of many articles of the Directive 2016/97, received in Italy with D.Lgs. May 68/2018:

- may the premium increase without agreement by the weak contractor (insured)?
- Or it should be considered refunding part of the premiums in case of progressive risk reductions, initially fixed constant (at a sort of «maximum» level) for the whole duration of the contract?

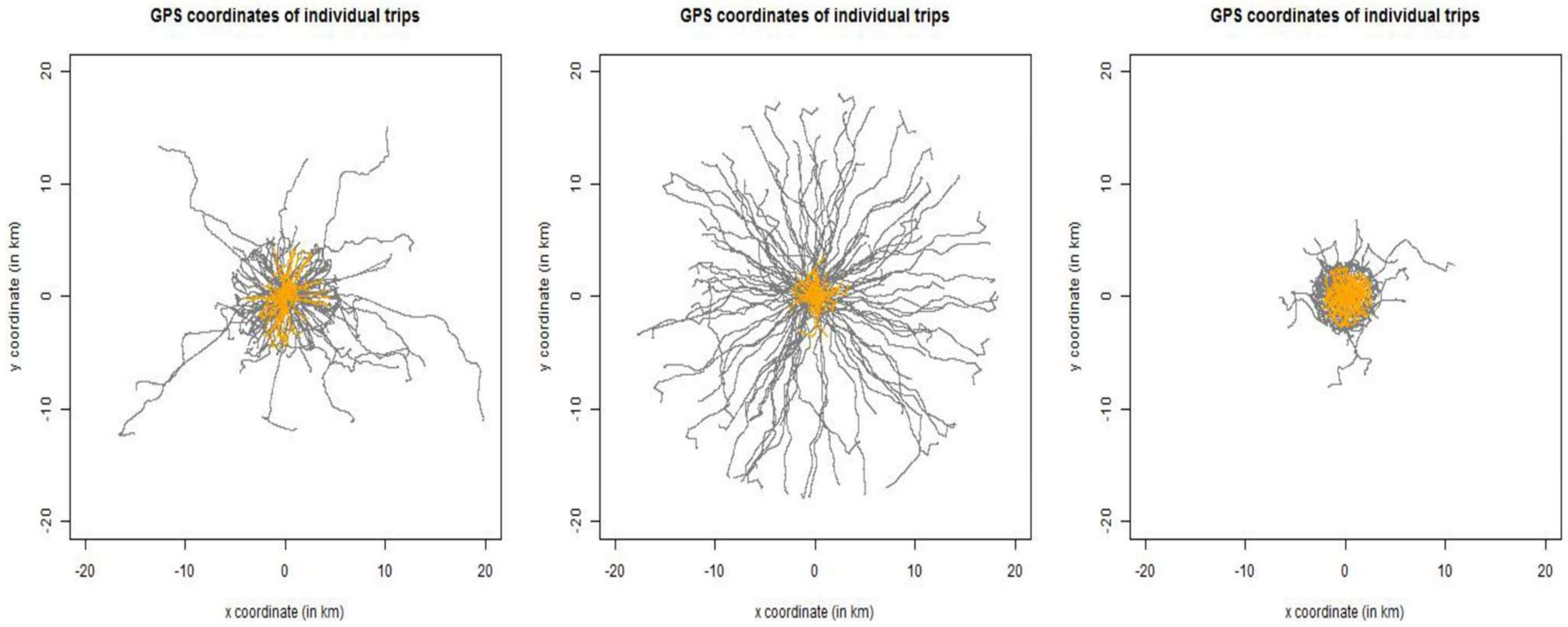
Other examples of Index based insurance

Various other examples of Index based insurance, with a smart contracting approach based on Blockchain.

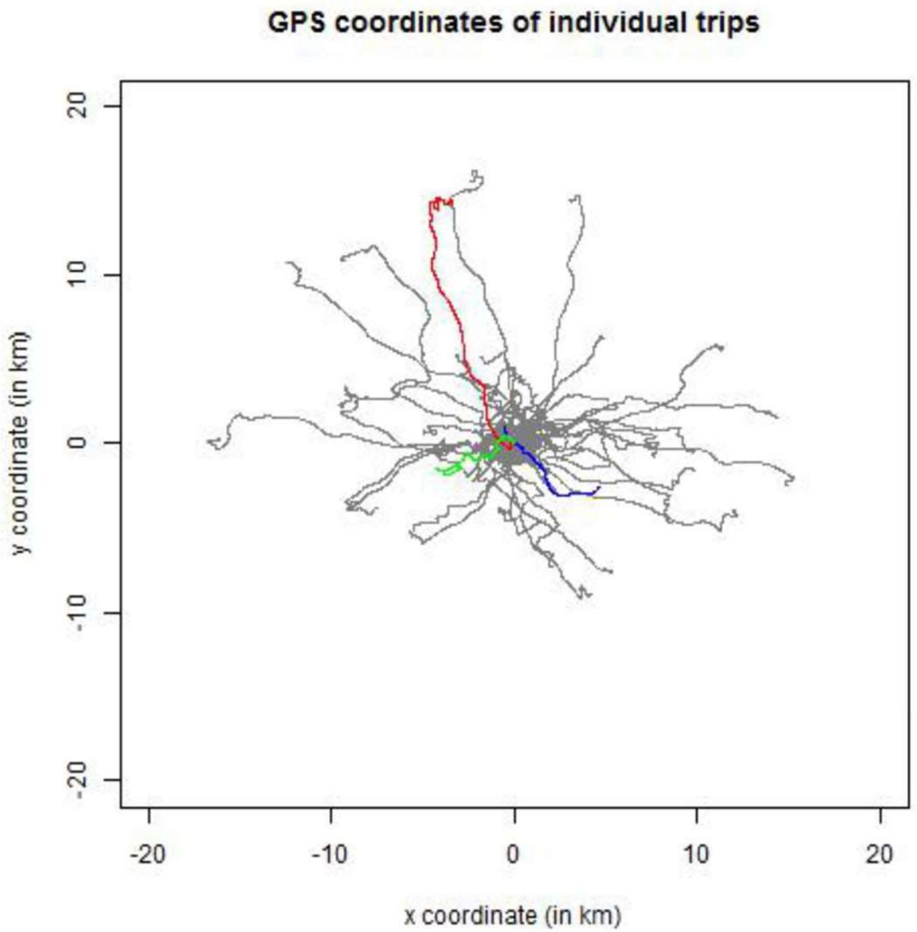
1) Flight delays insurance: launched by AXA, Fizzy from 2018 (end in 2020, even due to pandemic), based on the registered arrival time of a flight, with an automatic refund of a fixed amount in case of delay. Completely managed using Blockchain and Bitcoin as monetary unit.
2) Pandemic bonds, (one issued by Chinese Government in 2017 with maturity july 2020: 3 months before the OMS declared the pandemic state and this affect the cash flows of such bond) they naturally can be settled considering index based measure of pandemic.
3) Motorvehicle insurance based on Black Boxes: «pay as you go» based on recording specific risk indexes, as road types, strong brakes, speed peaks, …

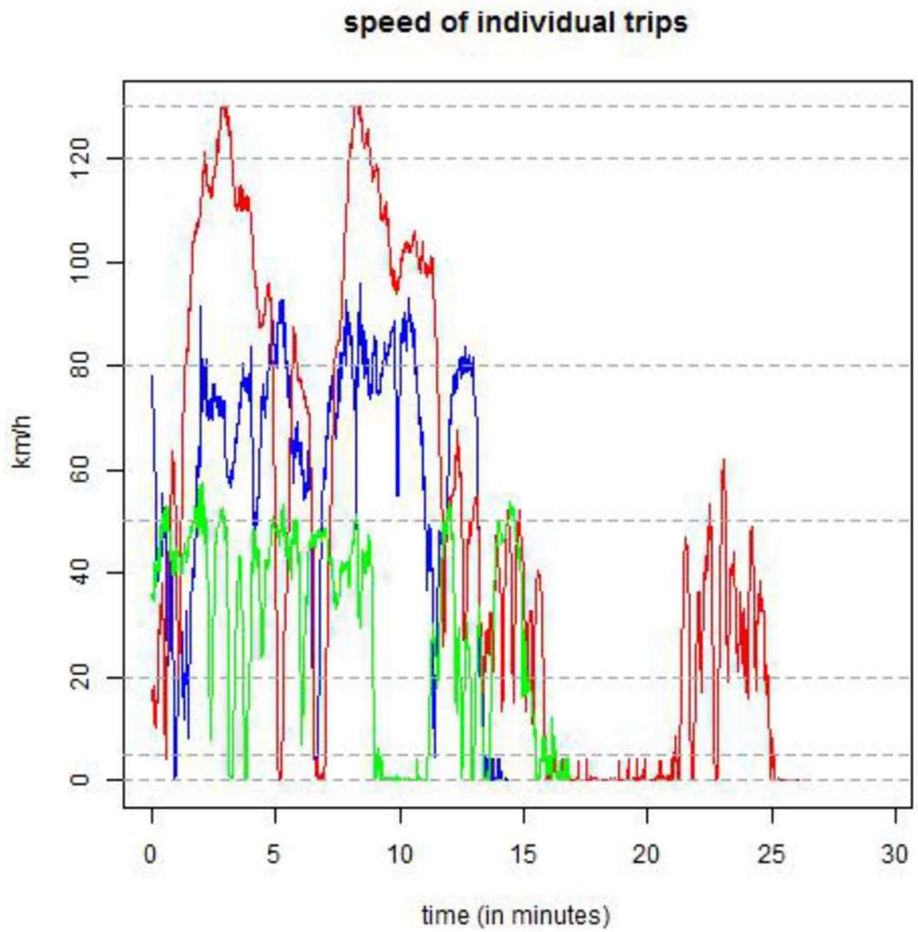
Black Boxes data: geographical maps for 3 drivers

Driver A　　Driver B　　Driver C

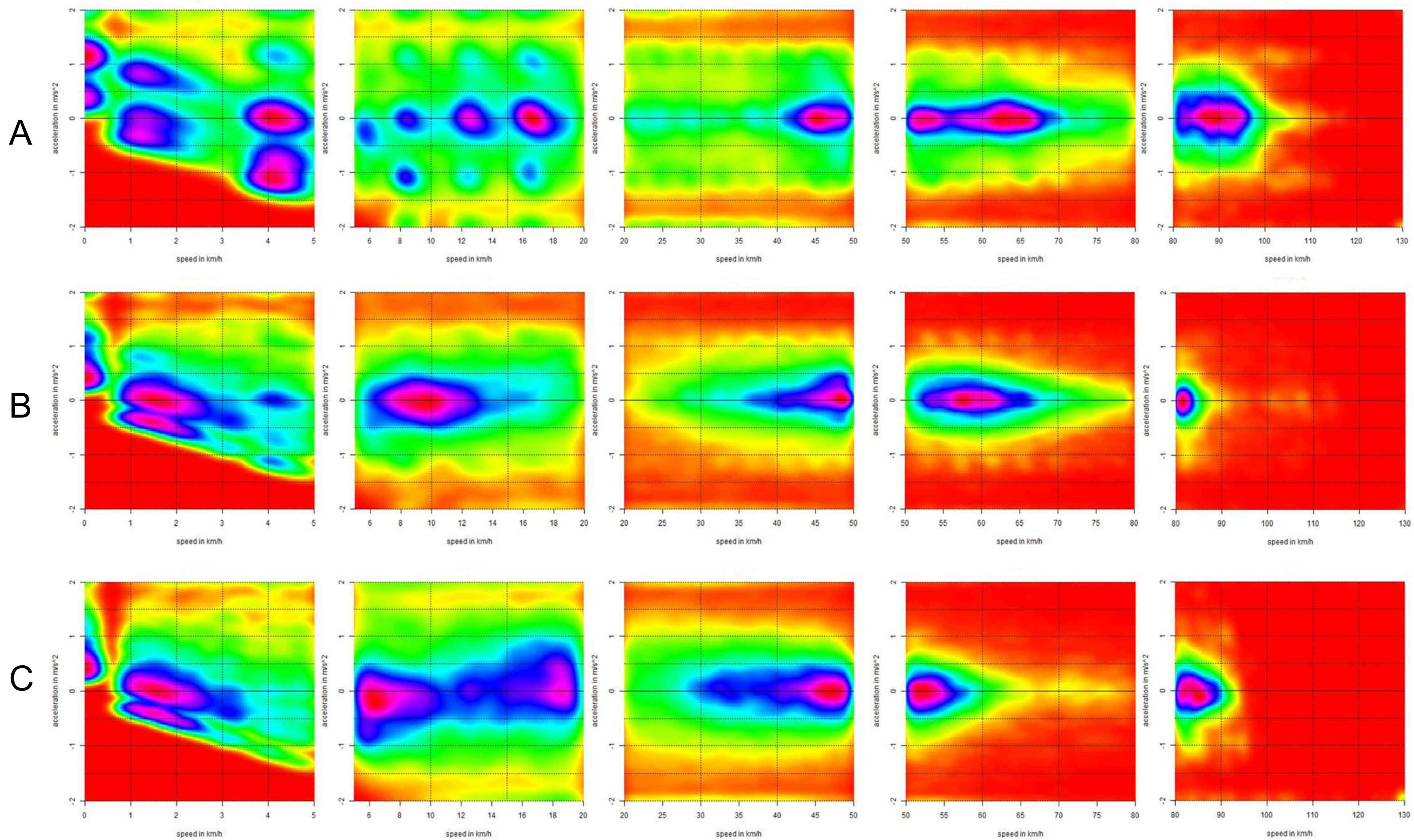


Black Box data:
geographical maps and speed recording

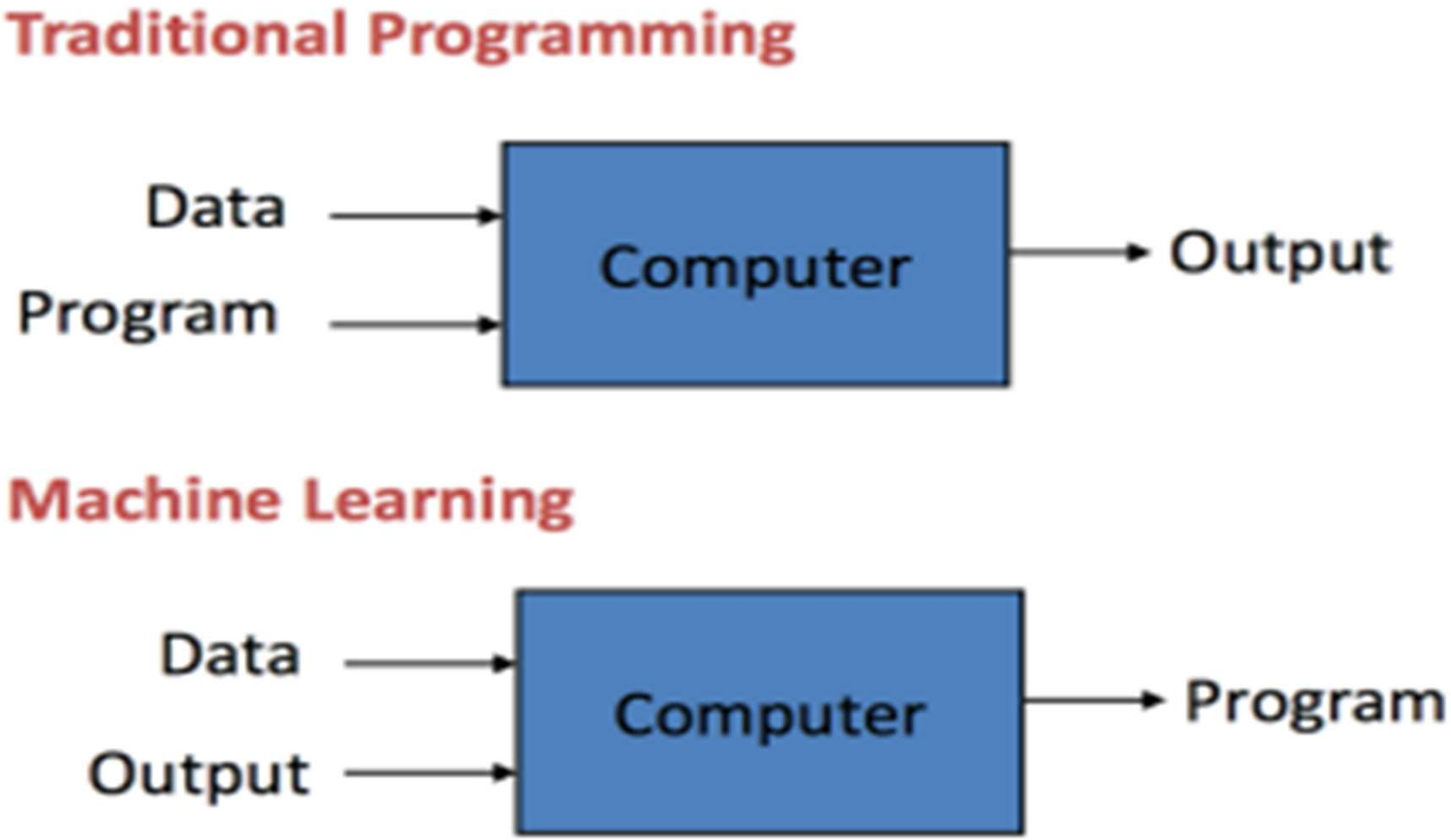




Black Box RC data: brakes and accelerations recording



Learning by data: Machine Learning



Machine Learning: classification by goal

Classification: identify the belonging of an element to a class (Logistic regression, Support Vector Machine, Decision trees, Neural networks)

Regression: The model output is a number (continuous or discrete) to be approximated by a function of the input data (Linear Regression, GLM, Generalized Additive Models, …)

Clustering: grouping a dataset into groups that are not known a priori (k-means, k-medoids, hierarchical clustering)

Times Series: specific algorithms for time series that allow you to make predictions on the future trend of the output (ARIMA, trend, seasonality)

Machine Learning: classification for learning modeand technique

Two learning modes

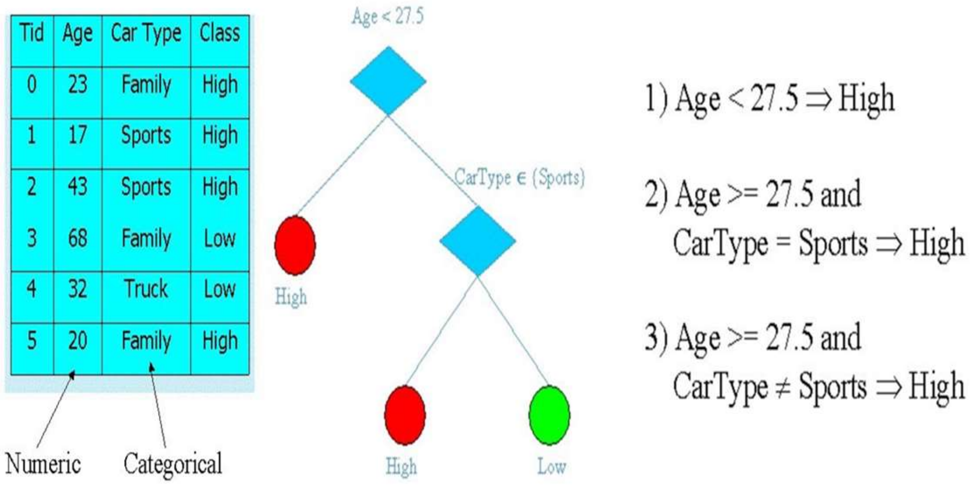
- supervisioned: use input and output data to define the relationship between them (classification and regression algorithms)

- not supervisioned: they only use input data and do not use an output, which may not even exist (clustering algorithms)

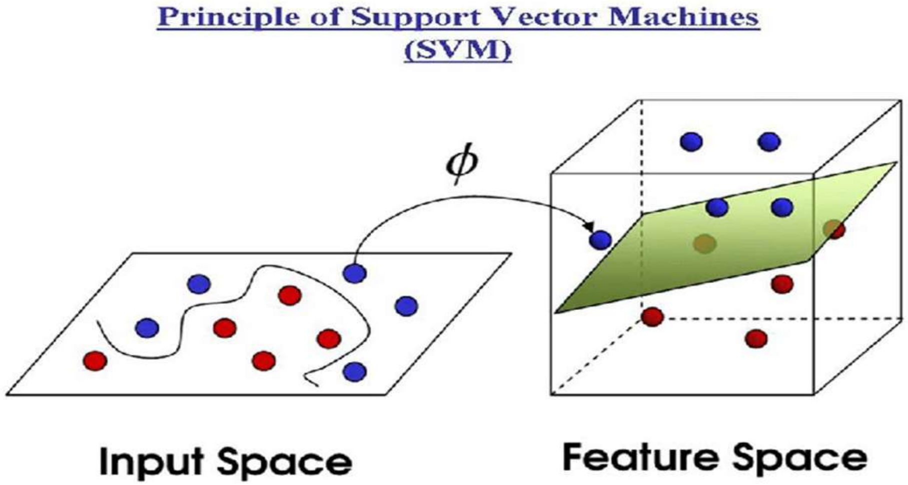
Many techniques: Regression, distance based, bayesian and clustering algorithms, neural networks, …

Algoritmi di Machine Learning

Tree



Classification



Clustering