SMART GLOBAL ECOSYSTEMS +SNGULAR

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CONFERENCE
ARTIFICIAL INTELLIGENCE AND ECOSYSTEMS MANAGEMENT

Artificial Intelligence in Forest Management: unpaved road

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OUTLINE

- Introduction
- AI relevant technologies
- Forest Management actions where AI can be relevant
- Bottlenecks in AI use in Forest Management
- Developments/Challenges ahead
- Evaluation of benefits/drawbacks
- AI as foresters' companions
- Ethical and Environmental implications

INTRODUCTION

- Forest management involves the integration of silvicultural practices and economic concepts in such a way as to best achieve a stakeholders' objectives

Adapted from Bettinger et al 2009

- Inspiring ideas for Forest Management:
  - Sustainability
  - Multifunctionality
  - Ecosystem services
  - Long term
  - Adaptation
  - Adaptive management
  - Trade-offs/synergies
  - Social engagement

INTRODUCTION

- Main questions in forest management (some examples)…
  - What ecosystems services will be obtained/priorized?
  - What is the desired species composition?
  - Wich the adequate silvicultural path for a given situation?
  - When apply silvicultural treatments to harvest/obtain ES? [ie, rotation age]
  - Where apply silvicultural treatments? [spatial dimensión]
  - How apply selected silvicultural paths? [Thinning, final harvest, continuous cover…]

INTRODUCTION

- Artificial intelligence is a groundbreaking techology that will change the way we conduct our cognitive work in forestry

(and even the operational work through semiauthomatic/authomatic robots)

- We must distinguish between narrow AI and general AI

- Today we have at hands narrow AI systems, but we should be prepared for the advent of general AI systems

AI RELEVANT SUBFIELDS, APPROACHES & ALGORITHMS

- **Subfields** are application areas within the field of AI

Examples of interest for Forest Management

- Computer vision
- Natural language processing
- Speech recognition
- Sensor data
- Augmented reality
- Natural user interfaces

AI RELEVANT SUBFIELDS, APPROACHES & ALGORITHMS

- **Approaches** are strategies or high-level methodologies used to solve problems using AI

The most adequate approach depends on the problem and the available data.

- Machine learning
- Reinfforce learning
- Deep learning
- Path planning (optimization)
- Artificial neural networks (ANN)
- Bayesian networks
- Rule-based systems (if-then expert guess)
- Expert systems
- Swarm intelligence
- Evolutionary and Genetic algorithms
- Fuzzy logic
- Probalistic graphical models

AI RELEVANT SUBFIELDS, APPROACHES & ALGORITHMS

- **Algorithms** are specific methodologies (sometimes borrow, or based, from statistics or mathematics) applied within a concrete AI approach to solve problems in a specific domain (as forestry)

- AI algorithms can be classified as supervised learning, unsupervised learning, and reinforcement learning algorithms

Algorithms examples….

- Linear and logistic regression
- Markov chain
- Naive bayes
- Support vector machines
- Radom forest
- K-means clustering
- Gaussian mixture models
- K-nearest neighbor algorithm
- Convulutional Neural Networks (CNN)
- Recurrent Neural Networks (RNN)
- Generative Adversarial Networks (GANs)
- Long Short-Term Memory Network (LSTM)
- Feedforward Neural Networks (FNN)
- Recurrent Neural Network (RNN)
- Autoencoders
- ….

FOREST MANAGEMENT ACTIONS WHERE AI CAN BE RELEVANT

- Site classification (current and forecasting)
- Yield assessment and prediction
- Forest Inventory
- Harvest allocation/planning
- Stand Dynamic forecasting
- Hazard/risk assessment and prediction
- Illegal logging detection
- Management path analisis
- Processes automatization
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Development costs might render certain ideas uneconomical (for now), even if possible.

BOTTLENECKS IN AI USE IN FOREST MANAGEMENT

- Data availability
- Data privacy and ethical concerns
- Knowledge sharing
- AI literacy within the forestry community
- Computational resources required
- Outputs unreliability
- Costs (both in terms of money and energy)
- Integration with traditional forest management strategies

DEVELOPMENTS/CHALLENGES AHEAD

- Development of intelligent agents for Forest Management domain
- Availability of real-world case studies
- AI needs
  - Calculus power (ie HPC accesibility) and energy
  - Reliable datasets
  - Algorithm Engineers
  - Domain experts knowledge
- Data privacy and ethical concerns

EVALUATION OF POTENTIAL BENEFITS/DRAWBACKS

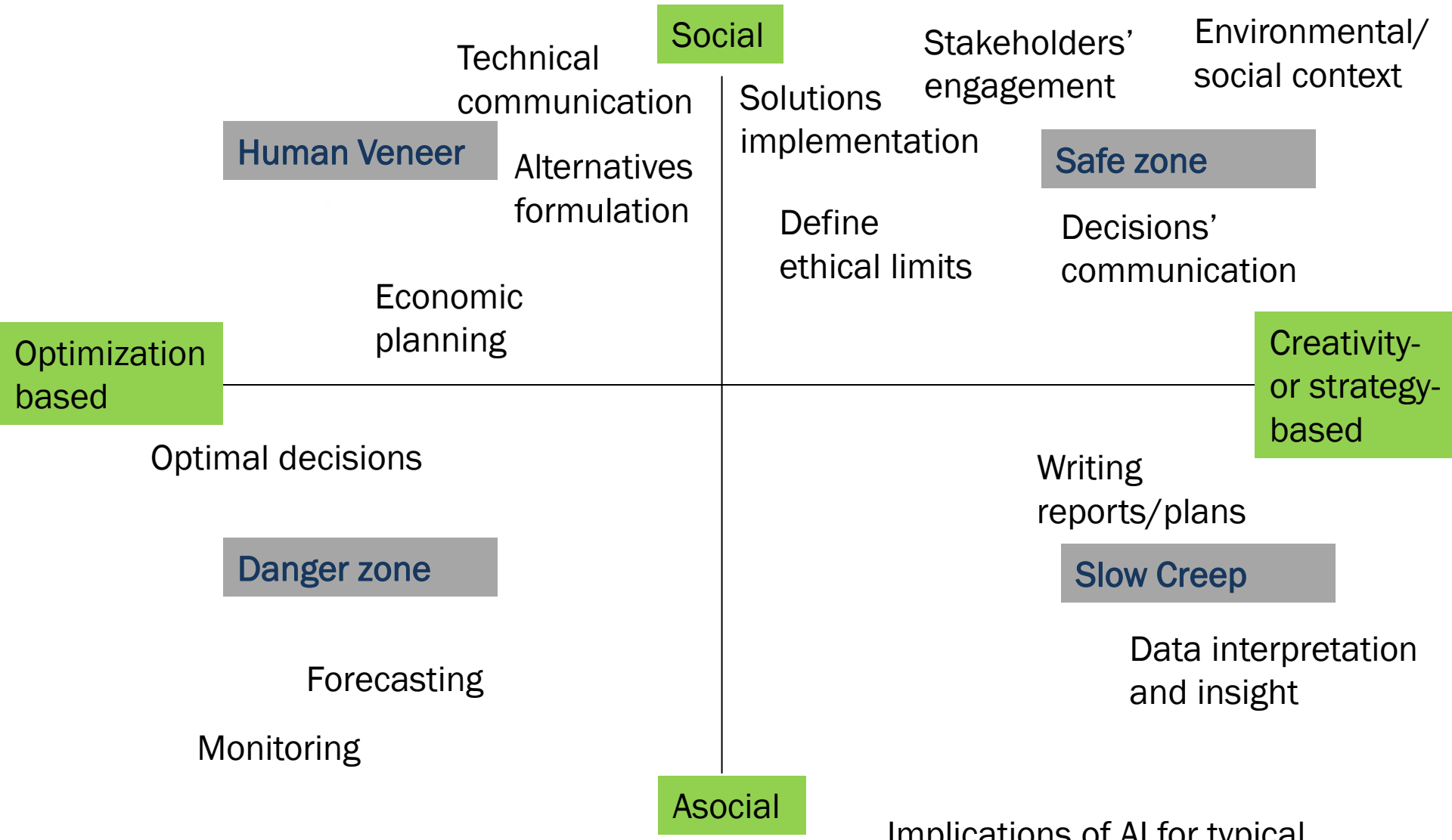
- BENEFITS
  - Increase efficiency
  - Better decision making
  - Improved monitoring
  - Increase sustainablity

- DRAWBACKS
  - High cost
  - Algorithm bias
  - Lack of accountability, explainability and transparency
  - Dependence on data quality
  - Privacy concerns
  - Technical challenges (specialized knowledge)

AI AS FORESTERS' COMPANIONS

- Basic knowlege for AI is right now enormous.
- It is time for domain applications.
- Foresters could not compete with AI-based machines in memorize data and optimize outputs.
- Foresters must concentrate in the local context (ethical, enviromental and social), social engagement and communication while using AI based machines to extend her/his capabilities.

AI AS FORESTERS' COMPANIONS



Implications of AI for typical forest management activities

Adapted from Kei-Fu Lee, 2018

AI AS FORESTERS' COMPANIONS

- AI as groundbreaking technology will impact the way we train professional foresters.
- Foresters must dive on AI to know its limits and use it within the local context for a correct AI-generated ouput interpretation
- To do this, a radical change is needed in forestry education.
- More emphasis should be given in forestry curricula to social aspects (communication, stakeholders engagement) and data science (data analysis, programming, problem solving and decision-making)

AI AS FORESTERS' COMPANIONS

- In practical terms foresters should be (soon):
  - Expert users of AI platforms (bachelor level foresters)
  - AI integration experts and AI user interface(UI)/user experience (UX) engineers (advance bachelor level foresters)
  - Expert trainers/adapters of AI platforms for forestry domain (Master level foresters)
  - Expert developers of AI solutions tailored for forestry domain (PhD level foresters)

ETHICAL AND ENVIROMENTAL IMPLICATIONS

- Increased energy comsuption in AI training and usage
- Increased carbon and water footprint due the needs of cooling the computer systems used
- Increased electronic hardware waste due to reduce of its operational life and the higher demand
- Jobs displacement, reduction and disappearance
- Potential bias in management alternative selection

LAST BUT NOT LEAST

AI opens up great opportunities to improve our understanding of forest ecosystems and facilitates responsible forest management by providing access to fundamental knowledge that would otherwise be difficult to obtain due to the findings and insights that AI facilitates in complex systems.

However, it is key to consider the ethical and social implications of integrating AI tools into forest management.

Thus, IA is both an opportunity and a challenge that must be approached with prudence and caution so that the benefits of its application outweigh the detriments it may cause.

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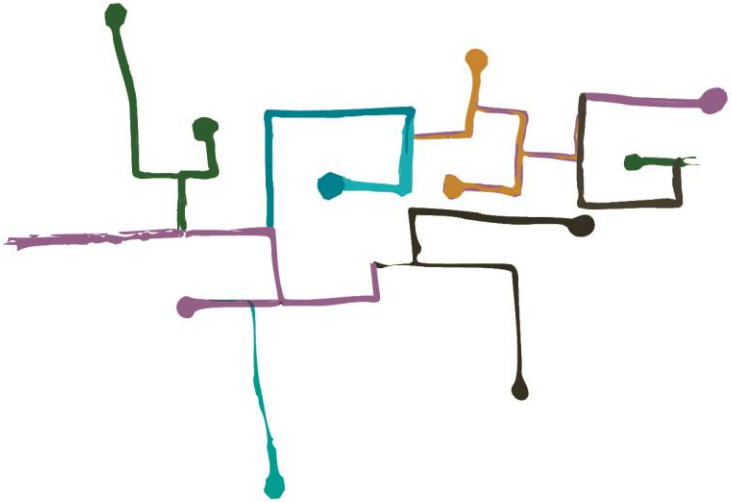
Thanks!!



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SCAN ME

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