Systems of Action

A stack model for capability classification

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Systems of Action

A class of systems that

- Can sense or observe a phenomena, process or machine
- Process observations and search for anomalies, undesired state changes and other deviations that must be dealt with.
- Plan and execute / (recommend execution of) actions to bring the observed phenomena, process or machine back to its desired operational state.
- Monitor effects of actions and re-plan if action did not have intended effect on process state

making better decisions under stress and uncertainty

The term was coined by Statoil in a attempt to illustrate the transition from record keeping to action optimisation.

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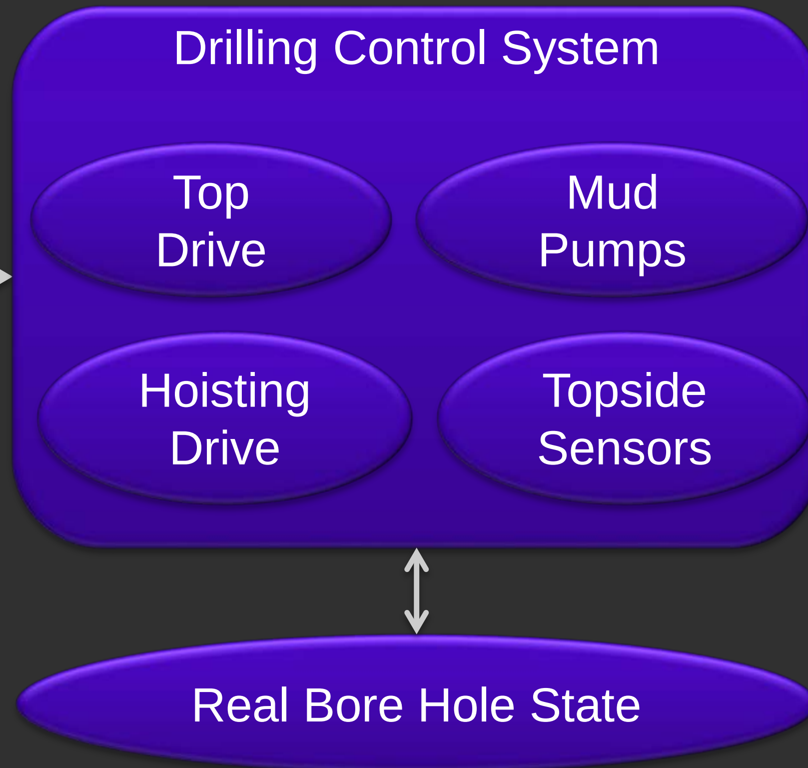
Motivation

Failed Safety Critical Decisions

- Situational awareness
- Trustworthiness
- Culture
- Decision quality

drilling



Manual Control
- Interpret state
- Perform tasks

A manually controlled process

a drillers perspective

What is the best action to take?

- I have to make frequent decisions and many of them depend upon readings from sensors that can be correct, noisy, random, unavailable, or in some other state.
- The decisions I have to make often have safety consequences, they certainly have economic consequences, and some are irreversible.
- At any point in time there may be three or four actions I could take based on my sense of what's happening on the rig
- I would like better support to determine how trustworthy my readings are, what the possible situations are and the consequences of each action.

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the weakest point

Human brain - planets most sophisticated and vulnerable system of action

- Emotions trumps facts (irrationality)
- Limited processing capacity
- Need to rest, easily bored
- Inconsistency across exemplars
- Creative, easily distracted
- Values (ethics and morale)
- Mental illness (irrationality)

How to avoid clusterfucks?

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add active computer support

Intelligent Drilling Assistant

Recommend actions in context of process state

Real-time data

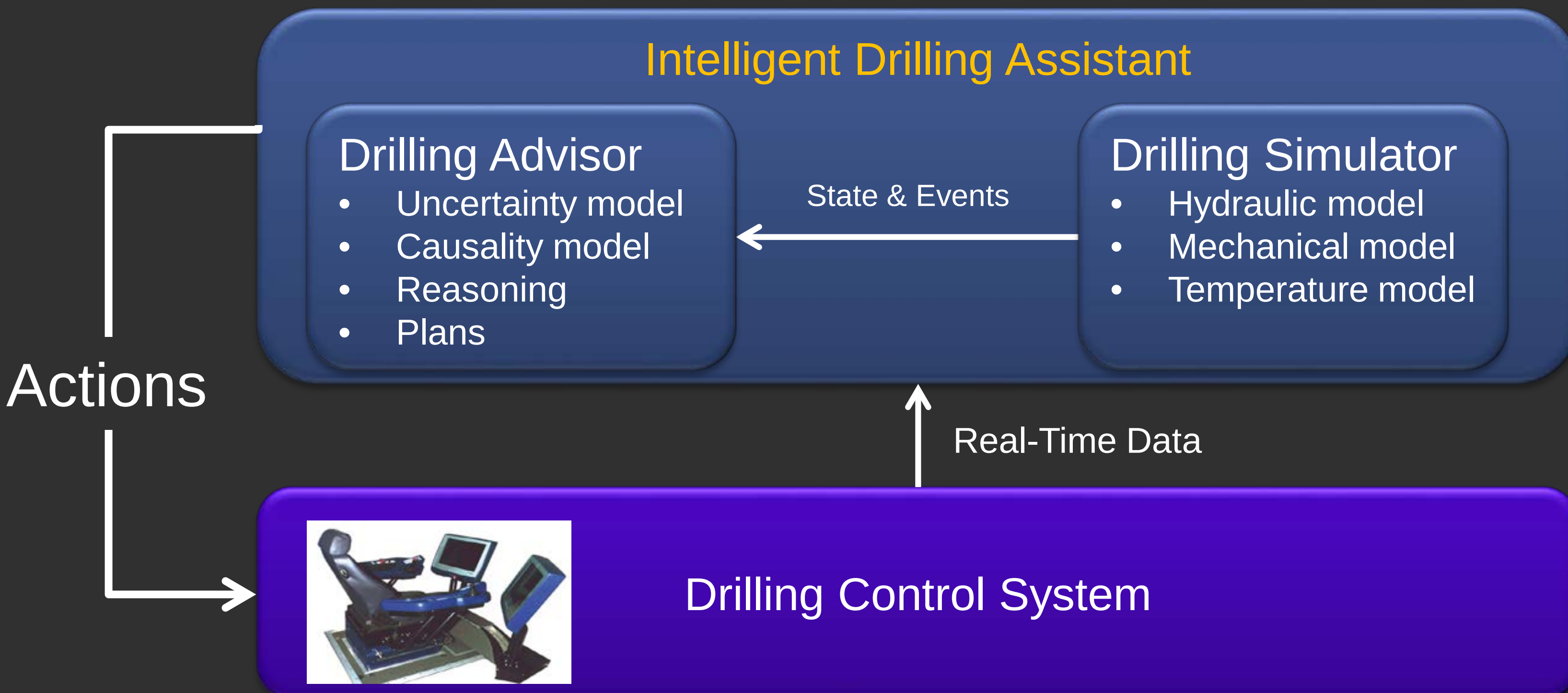
Manual Control

Drilling Control System

- Top Drive
- Mud Pups
- Hoisting Drive
- Topside Sensors

Real Bore Hole State

the drilling assistant



Action to be executed by human, but concept opens up for more computer control in the future.

i.e. Drilling advisor can be turned into “synthetic driller”.

the problem

How to architect systems of action?

How to make the architecture communicable?

How to structure requirements?

How to structure solutions?

What capabilities do we need?

What dependencies do we have?

Where are the interfaces?

What components to use?

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a capability stack

Increasingly Actionable Information

Global Action Optimization	What is the best action to take for the business?
Local Action Optimization	What is the best action to take for control or safety?
Situational Awareness	What is the process state and where is it heading?
Uncertainty and Validation	What do we know for certain and what are we estimating?
Physical System Behavior	What can we infer about performance and changes in the physical system?
Physical System Sensing	What are we measuring directly, with what accuracy?

Thanks to Dr. Matthew Barry, www.softisms.com and Dr. Andrew Lucas AOS www.aosgrp.com for valuable contributions

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technological perspective

Increasingly Actionable Information

Global Action Optimization	Well-lifecycle planning and scheduling, resource management tools.
Local Action Optimization	Task-level planning and scheduling; decision utility models; ideal action under uncertainty; procedure synthesis
Situational Awareness	State estimation and transition tracking; hazardous state identification; human operator models; state-space representations
Uncertainty and Validation	Probabilistic and statistical models; confidence measures
Physical System Behavior	Fluid dynamics models; geophysical models; Equipment models
Physical System Sensing	Direct sensors and detectors; data stream acquisition and processing; calibration; distribution

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user perspective

Increasingly Actionable Information

Global Action Optimization	Global actions considered in context of best-available technical support and trustworthiness
Local Action Optimization	Less expertise required to convert processed information into ideal actions; irrelevant information hidden from action context; good technical support for action trustworthiness
Situational Awareness	System behavioral complexity reduced through decoupling and known planned interactions; reduced state confusion; some expertise required to map onto possible actions
Uncertainty and Validation	The degree of confidence in observations and inferences is well established; justifiable trustworthiness for action input
Physical System Behavior	Substantial expertise required to infer actions given changes in physical system behavior and interpretation of causal mechanisms
Physical System Sensing	Considerable expertise required to convert raw observations into actions; little technical support for action trustworthiness

domain specific perspective

Increasingly Actionable Information

Global Action Optimization	Business procedural agents for goal-directed operations resource management, conflict resolution, logistics, ordering, etc. Technology: intelligent agents.
Local Action Optimization	Procedural reasoning about operations; establishing operating goal, selecting procedures, executing procedures including workarounds. Computing and ranking idea operator actions under uncertainty. Technology: intelligent agents; action utility models.
Situational Awareness	Procedural reasoning about operator's mindset. Adjusting presented content to maximize relevant information. Technology: intelligent agents; intelligent cognitive agents; expected value of revealed information.
Uncertainty and Validation	Computed confidence intervals for sensor validation and diagnostic testing. Probability density mapping onto fault states. Technology: causal probabilistic networks; system state models.
Physical System Behavior	Causal probabilistic network models (Bayesian reasoning) process observations and prior probabilities into (a) latent variables or (b) computed probability densities. Technology: causal probabilistic networks.
Physical System Sensing	N/A

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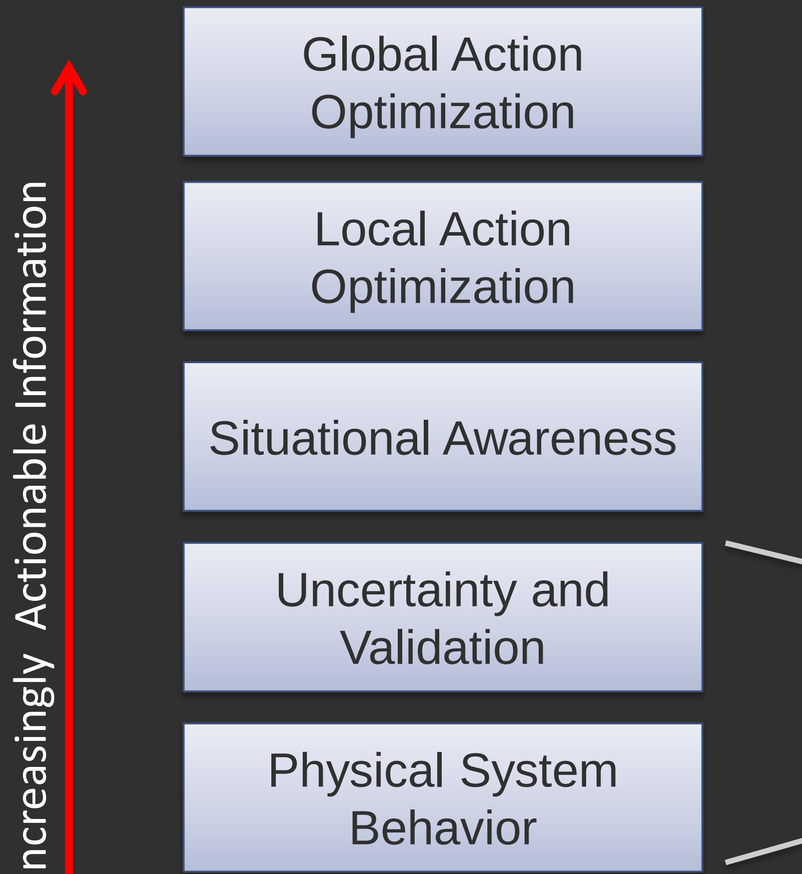
product integration perspective



Intelligent agents: AOS JACK
Intelligent analytics: Enrich Analytics Platform

Intelligent agents: AOS JACK, AOS C-BDI
Utility models: Statoil internal
Middleware: Any event-driven

Intelligent agents: AOS JACK, AOS C-BDI
Cognitive agents: AOS CoJACK
Expected value revealed information: BN + Utility model + Action model
Middleware: Any event-driven

Causal probabilistic networks: Hugin Expert, Norsys Netica, UCLA SamIam, Mathworks Matlab Bayes Net Toolbox, Bayes Server, R graphical models
Utility models: Statoil internal
System state models: Safeware Engineering SpecTRM, UML SysML, NASA JPL MDS, Mathworks Simulink Stateflow
Middleware: Any event-driven

Notes: A) Utility models are simply tables of cost values assigned to actions or outcomes, so we do not identify specific commercial tools for these. These tables can be done with Excel or with the companion BN tools. B) EVRI is a way to use BN + utility model programming to control displayed content; there are no known commercial products. C) MDS product requires license from Caltech. D) SamIam product requires license from UCLA for commercial use. Dr. Matt Barry.

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Building Blocks perspective

Global Action Optimization

Local Action Optimization

Situational Awareness

Uncertainty and Validation

Physical System Behavior

Physical System Sensing

Automated planning and scheduling

Machine learning (Bayesian) + Physics (Cyb)

Decision / game theory

Rational agent

- has goals
- models uncertainty
- chooses action with optimal expected outcome for itself
- Examples:
  - human (on a good day)
  - intelligent software agent

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Summary

Systems of Action

Analyse data in context of process and recommends the best possible action

Combines cybernetics, AI and visualisation technologies

How to architect?

Capability stack

Helps architecting systems of action

Simplifies stakeholder communication

Q & A