





# Operations Recognition at Drill-Rigs

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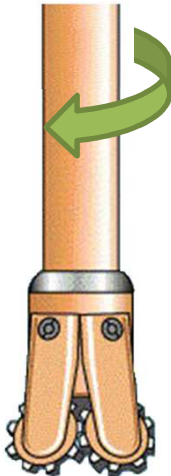
# Outline

-  The drilling process
-  Drilling real-time data
-  Drilling Activity breakdown
-  Multilevel Classification
  - *Data Preparation*
  - *Feature Extraction*
  - *Feature Selection*
  - *Classifier Training*

# The Drilling Process - Basic Actions

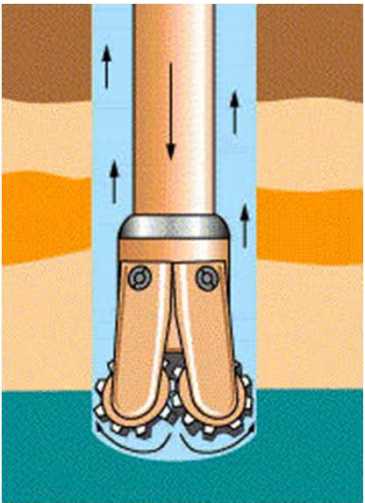
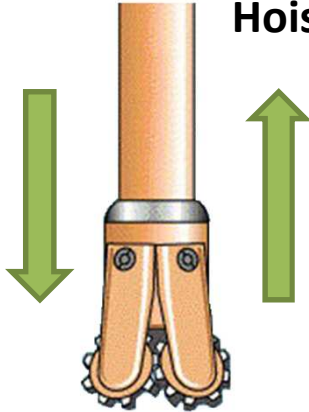
## Rotating the drill string

Rotating System



## Moving the drill string

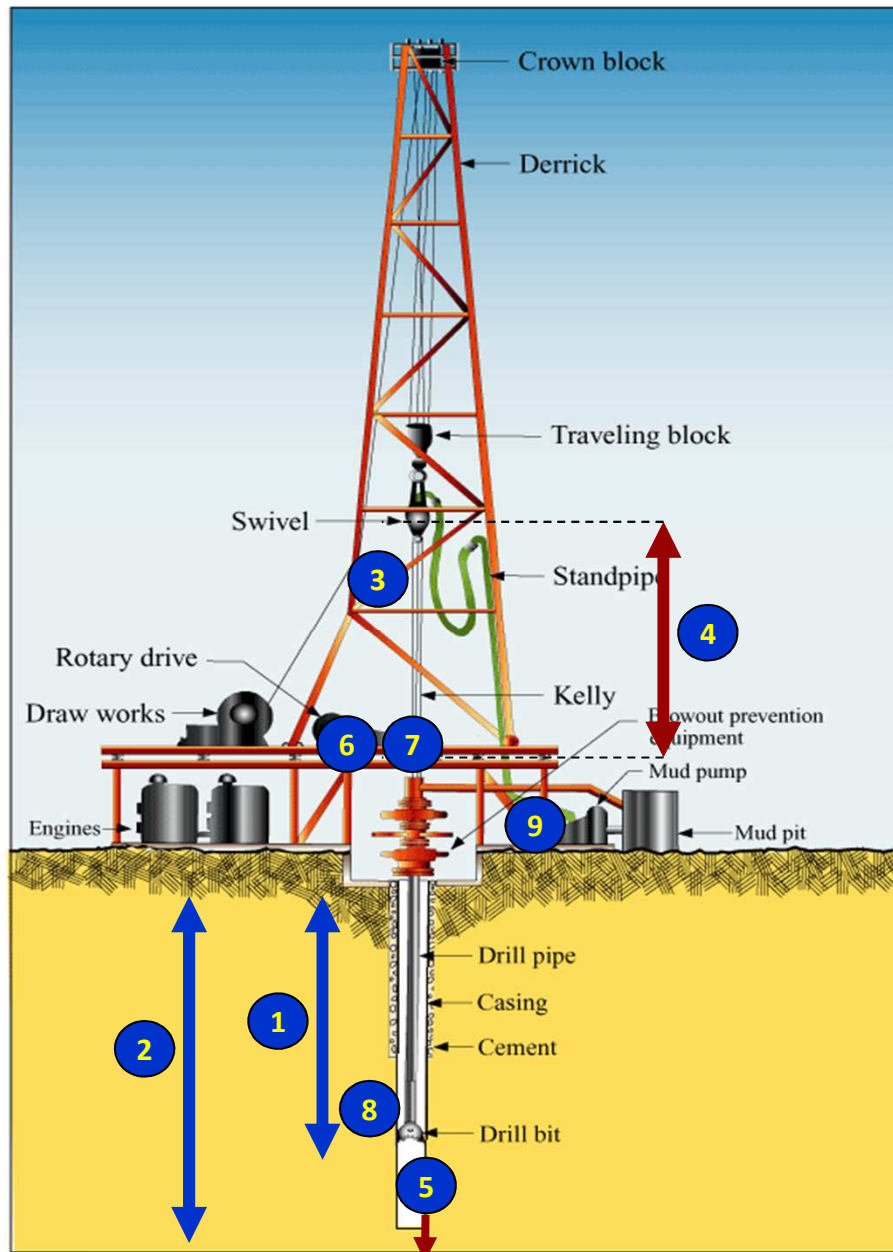
Hoisting System



## Circulating the drilling mud

Circulation System

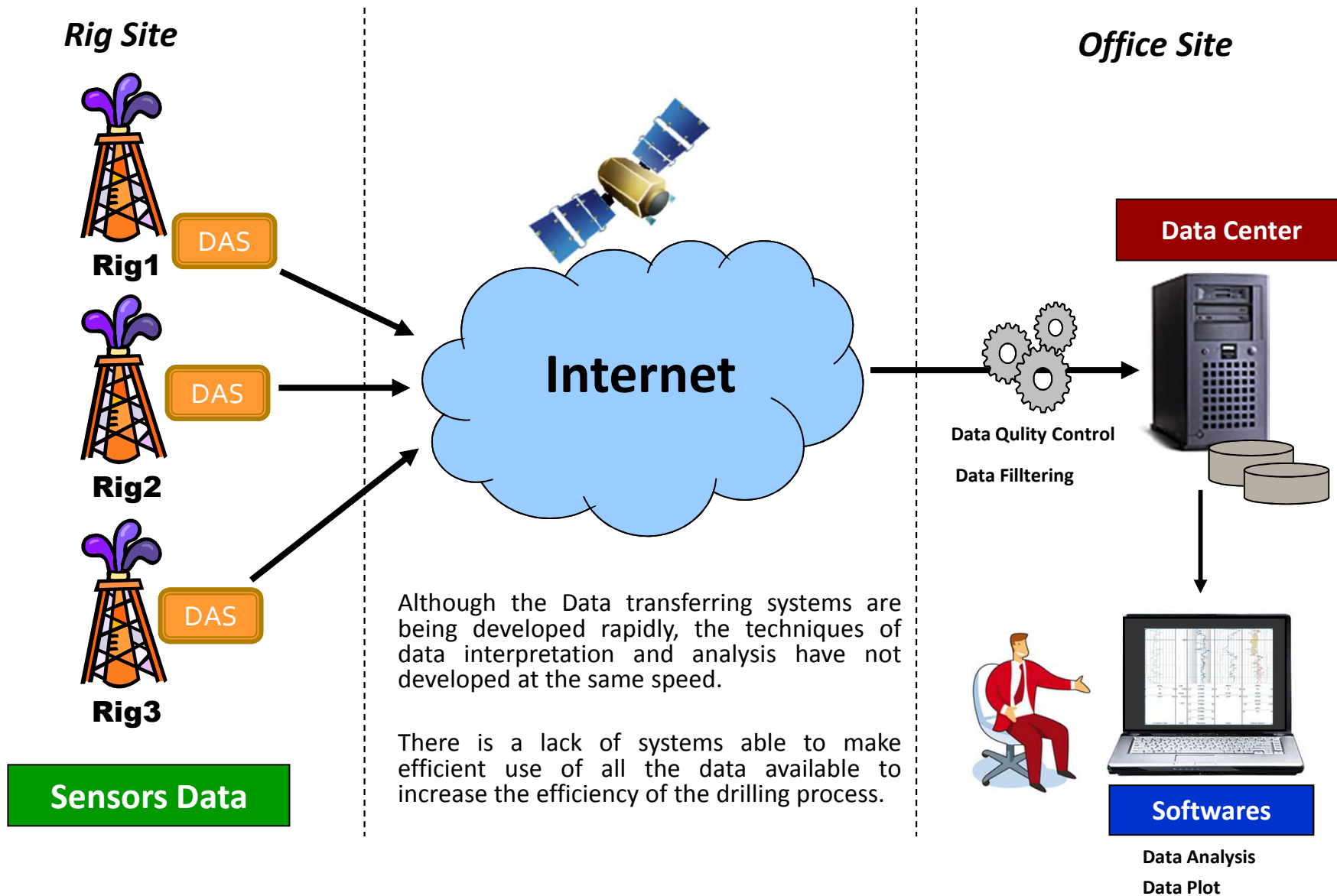
# Drilling Real-time Data



- Many mechanical parameters are continuously measured during drilling oil wells.
- These parameters are measured by a group of sensors located around the drilling rig and wired to a measurement system called a mud-logging system.

1. Bit Depth
2. Hole Depth
3. Hook Load
4. Block Position
5. Rate of Penetration (ROP)
6. Rotary Speed
7. Rotary Torque
8. Weight on Bit
9. Mud Flow

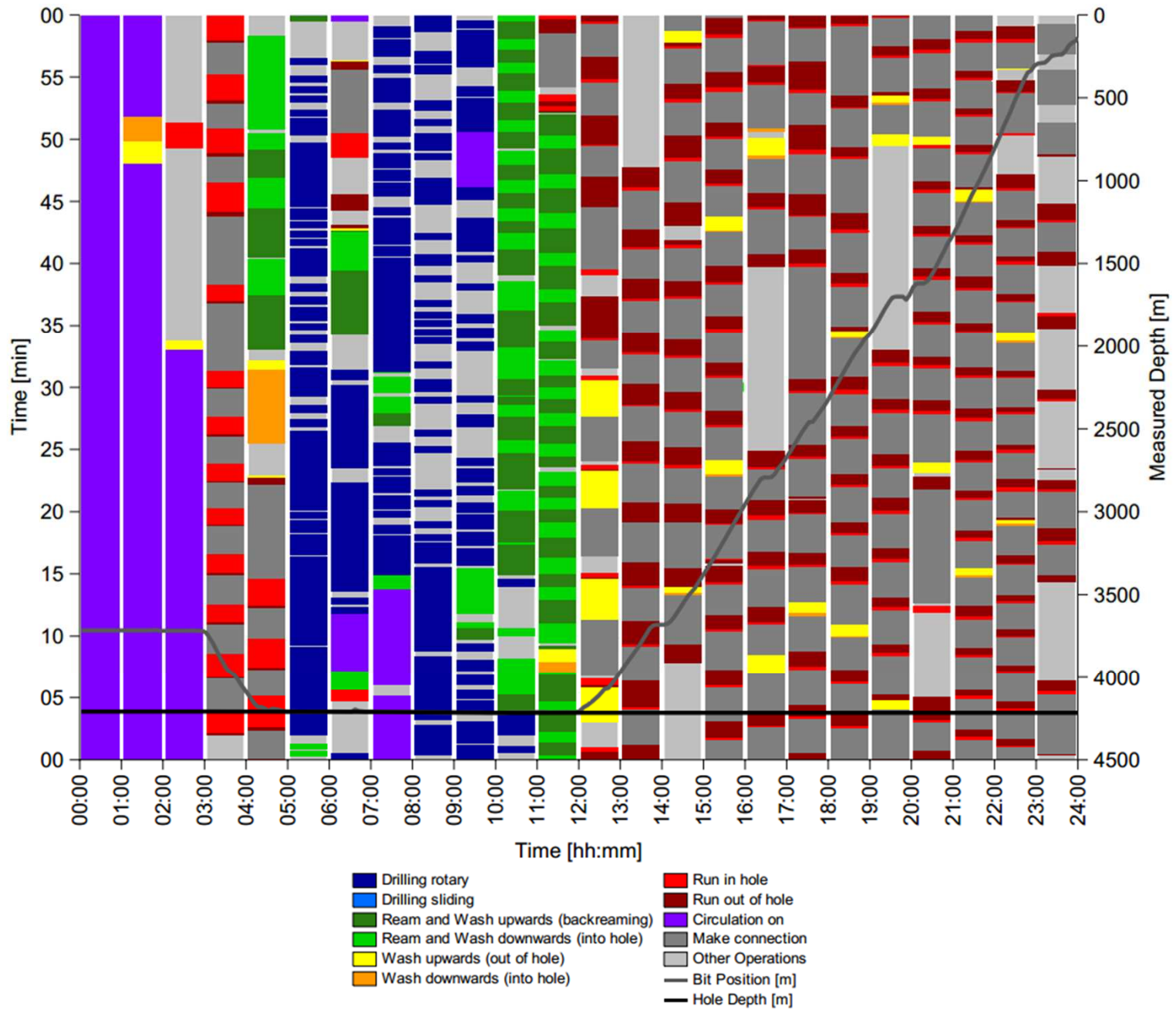
# Drilling Real-Time Data



# Improving the Drilling process

- Drilling oil wells is a costly process.
  - Improving this process is an essential task for the operators.
- We can improve only what we can measure
- Improving the drilling process relies on performance analysis that is primarily based on **activity breakdowns**.





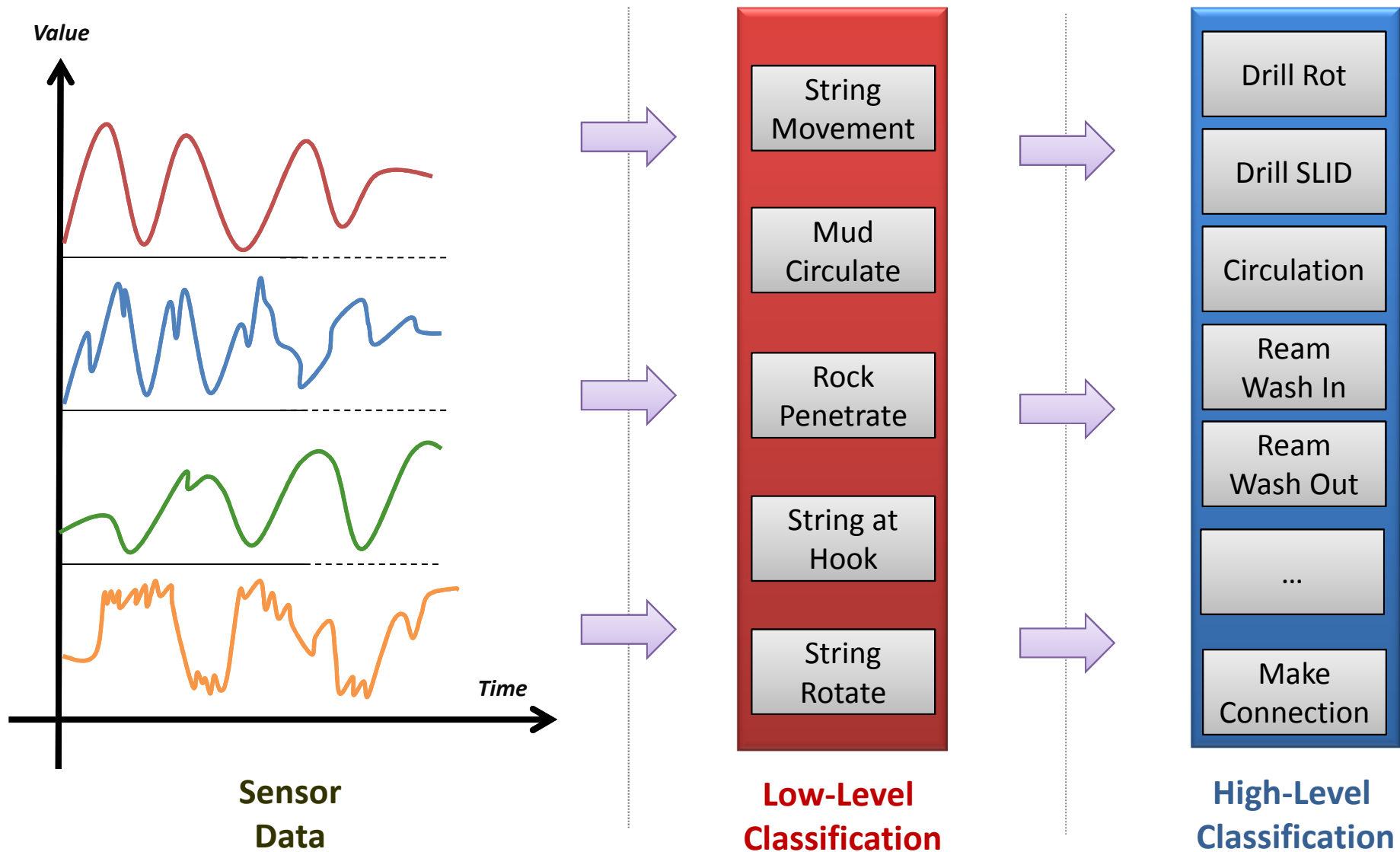
Operation Recognition Results for one Day

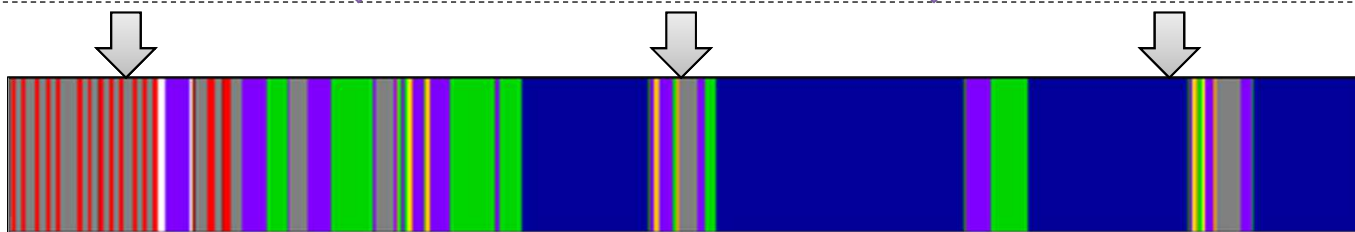
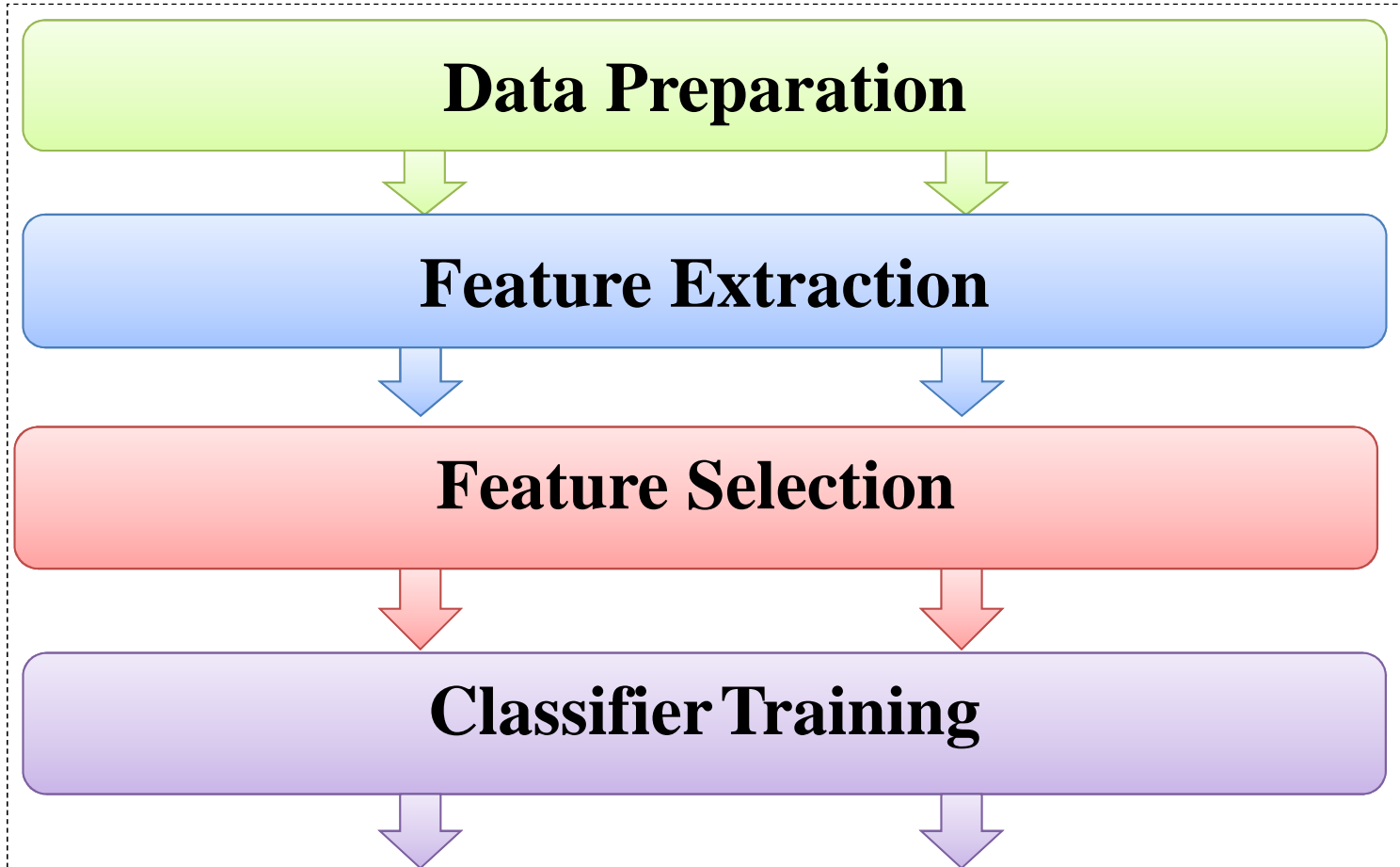
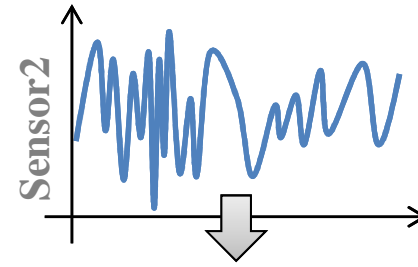
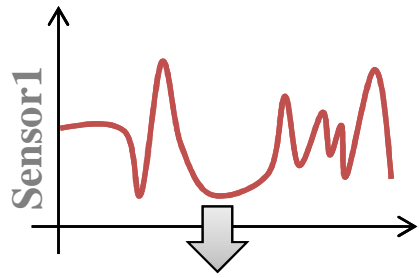


# Improving the Drilling process

- Operations recognition systems break the total drilling time down into list of well-defined operations like drilling, rotating, make connection, etc.
- The proposed method supports the extraction of knowledge from sensor data to:
  - improve productivity and performance,
  - prevent from mistakes and
  - resolve problems faster.

# Multilevel Classification





**Operations**

# Data Preperation

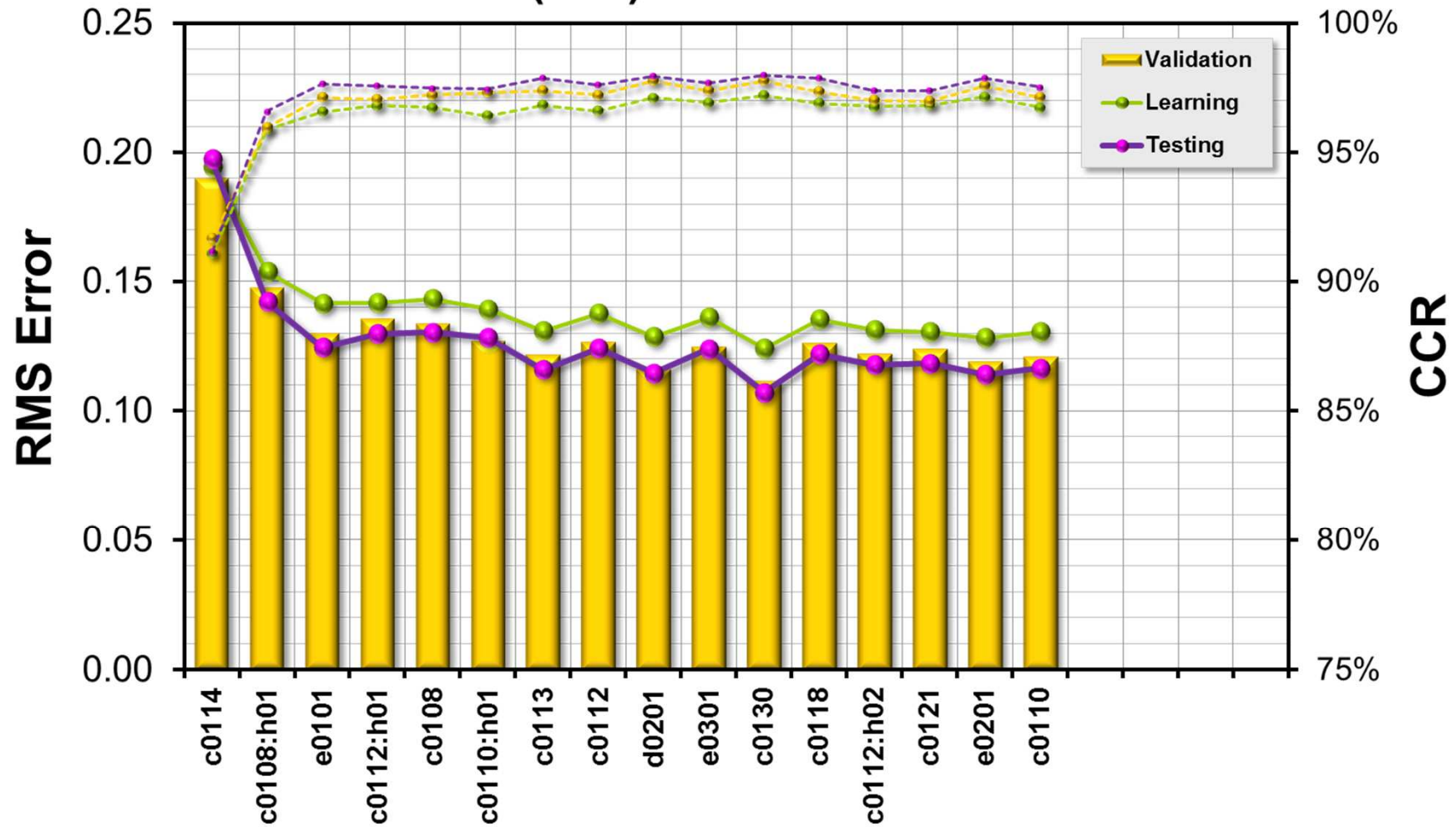
- The sensor data are not directly ready for building the classification models.
- These data contain **outliers** and **missing values** that will influence the accuracy of the features calculation.
- Data cleansing is an elementary step that should precede all others machine learning steps.
- Two subtasks were executed:
  - Identification and handling of missing values
  - Identification and handling of outliers

# Feature Extraction

- Physical features are calculated from the sensor data.
  - Block Speed
  - String Mass
  - Bit Speed
  - Bit Acceleration
  - Etc.

# Feature Selection

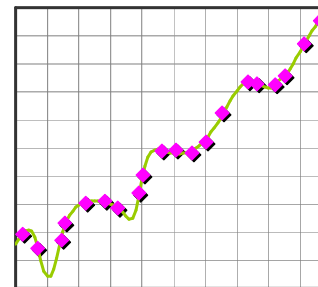
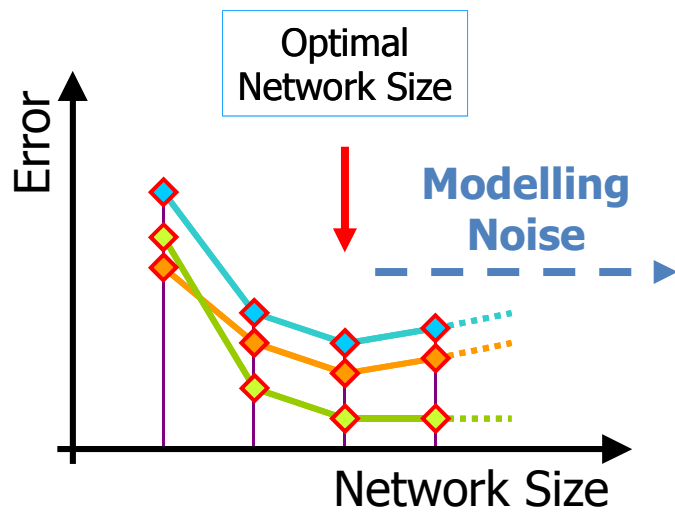
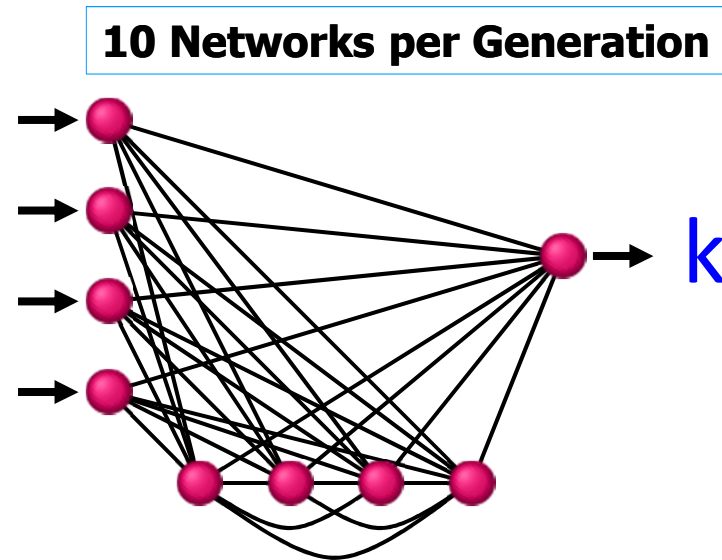
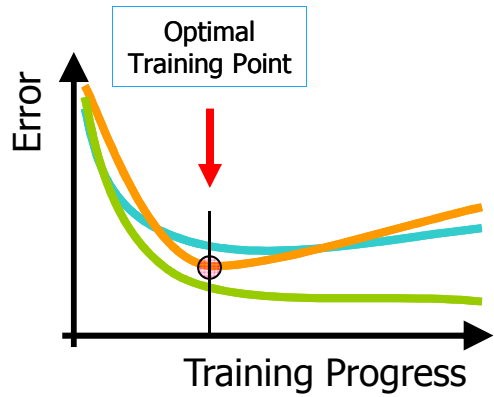
TDL-S055-R005 (DRI) C10+X06+9xH STn



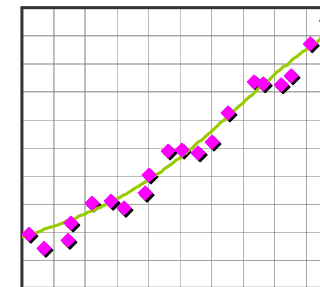
C0108	C0110	C0112	C0114	C0118	C0120	C0121	C0130	C0113	C0116	D0101	D0201	D0301	E0101	E0201	E0301
mdBit	mdHole	posBlock	hkldAv	tqAv	rpmAv	presPumpA v	flowInAv	ropAv	wobAv	mdHole- mdBit	mdHole+posBlo mdBit+posBloc ck	k	tqav* rpmav	presumpav* fl owinav	ropav* wobav

# Classifier Training

Prevention of Overtraining & Oversizing



Oversized



Regular

# Experimental Results

## Confusion Matrix String Movement

stn:L (e1)	97.2%	
{d}	{s}	{u}
98.6%	97.0%	75.4%
<b>5503</b>	24	46
34	<b>1029</b>	39
45	8	<b>260</b>
79	32	85
5582	1061	345

stn:T (e1)	98.0%	
{d}	{s}	{u}
99.1%	97.0%	82.5%
<b>1835</b>	8	14
8	<b>353</b>	6
8	3	<b>94</b>
16	11	20
1851	364	114

stn:V (e1)	97.8%	
{d}	{s}	{u}
98.7%	97.5%	80.6%
<b>1850</b>	7	9
5	<b>349</b>	10
19	2	<b>79</b>
24	9	19
1874	358	98



# Acknowledgement

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THONHAUSER DATA ENGINEERING GMBH

