

Frischer Wind für ein bekanntes Thema – Klassifikation 4.0

AK Fernerkundung
Heidelberg, 4.-5.10.2018

Ruth Leska, GEOSYSTEMS GmbH

GEOSYSTEMS
THE GEOSPATIAL EXPERTS



GEOSYSTEMS ist Ihr Partner für
Geo-IT Lösungen und **Hexagon
Geospatial Platinum Partner**
mit herausragender Expertise in
Geodatenmanagement, Smart
M.Apps, GIS, Photogrammetrie
und Fernerkundung.





Portfolio



Hexagon Geospatial Portfolio

GEODATEN AUSWERTEN UND VERTEILEN



APPS ERSTELLEN & VERKAUFEN



M.App Portfolio

A simpler way to see your world

M.App Portfolio® ist eine cloudbasierte Plattform, die es den Hexagon Geospatial Partnern ermöglicht, **Hexagon Smart M.Apps zu entwerfen, zu bauen und zu veröffentlichen**. Das M.App Portfolio untergliedert sich in die M.App Foundation, das M.App Studio und den M.App Exchange Marktplatz.

M.App Enterprise® ist eine On-Premise-Plattform, um für Ihre Organisation **geographische Apps zu erstellen**. M.App Enterprise speichert Ihre Bilddaten, Vektoren und Punktwolken, Ihre Workflows, Analysen und Abfragen, und all das ist über eine einfach zu bedienende Nutzeroberfläche zugänglich.



GEOSYSTEMS Produkte

UAV-DATEN

Photogrammetrisch
prozessieren



ATMOSPHERE


korrigieren & Dunst
entfernen



SENTINEL-DATEN

downloaden & prozessieren



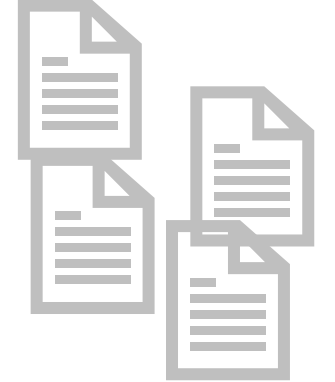
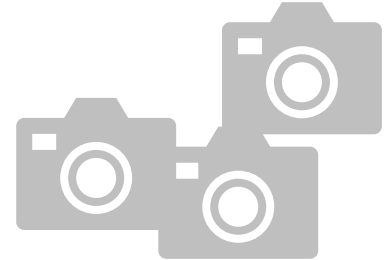
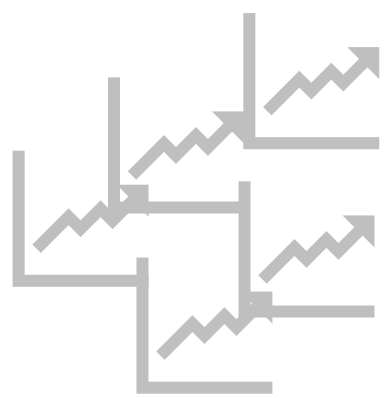
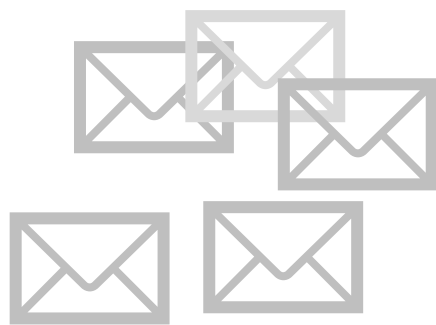
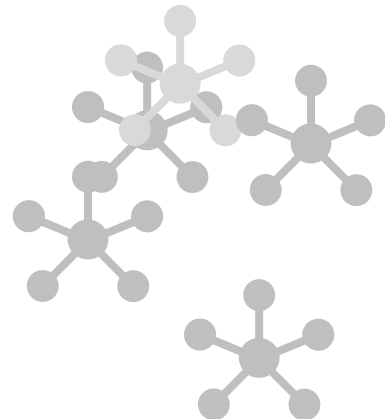


Give it to the machines and let them sort it out

Machine Learning und Deep Learning

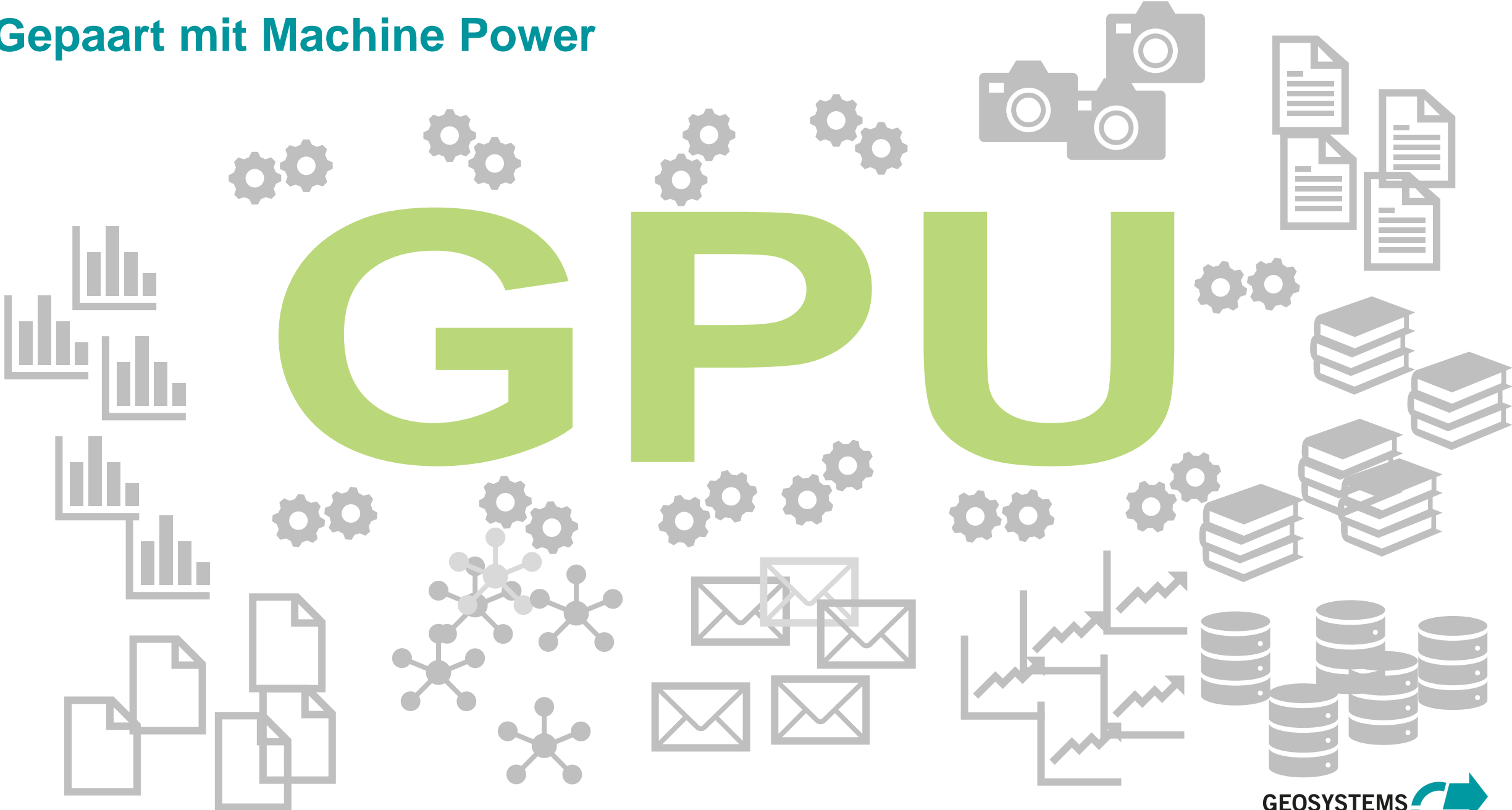
Ein großes Thema der letzten Jahre

BIG DATA



Gepaart mit Machine Power

GPU



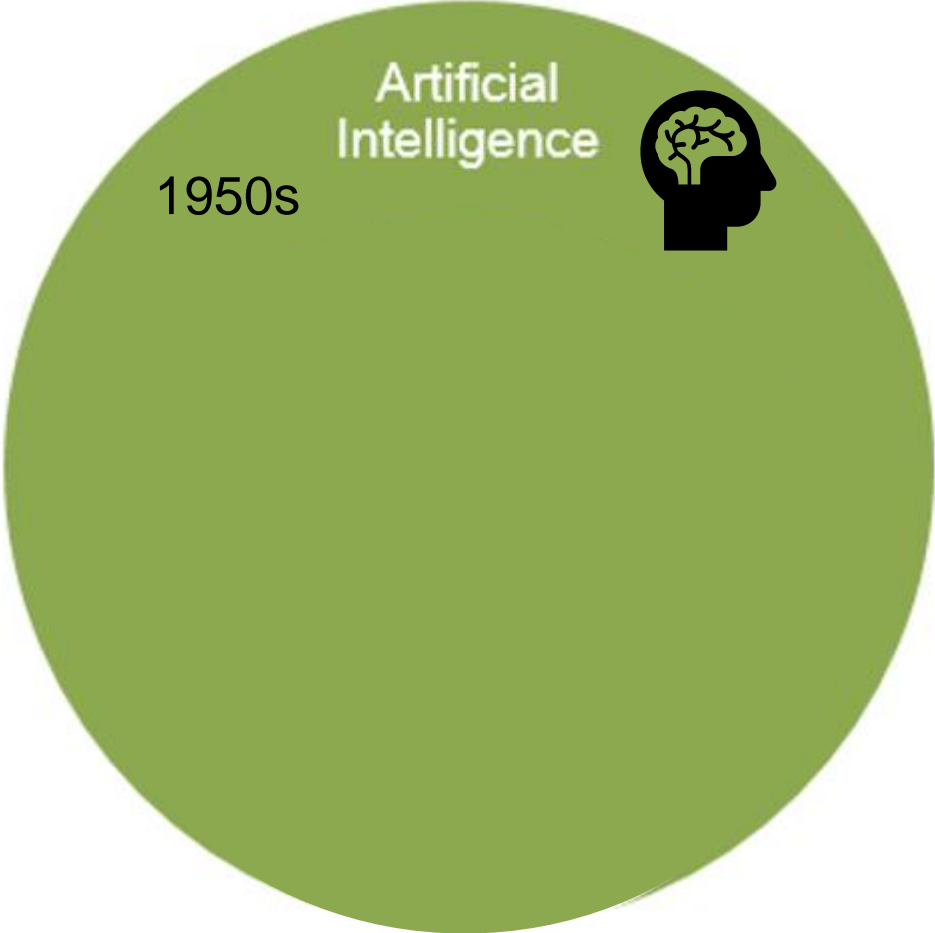
“Give it to the machines and let them sort it out”

➔ MACHINE LEARNING

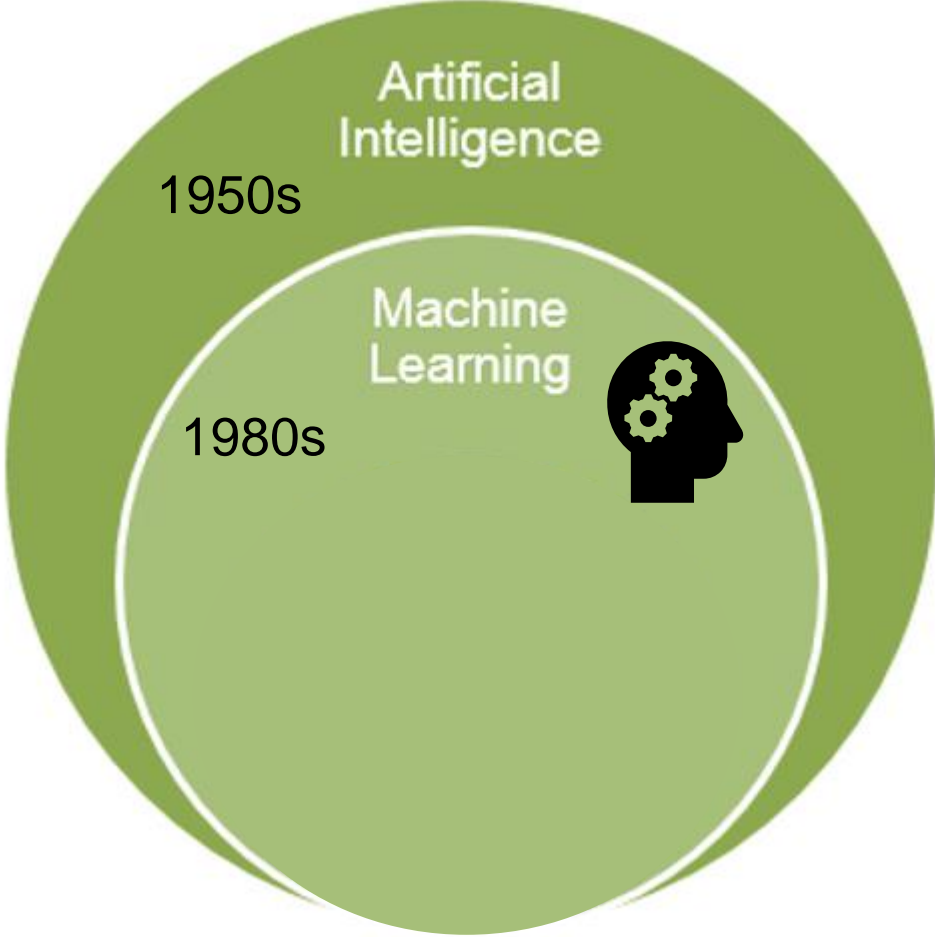


Machine Learning ist ein Ansatz, Daten anhand „unsichtbarer“ Muster zu erkennen – ohne zu wissen wie, wo und nach was zu suchen ist

Künstliche Intelligenz

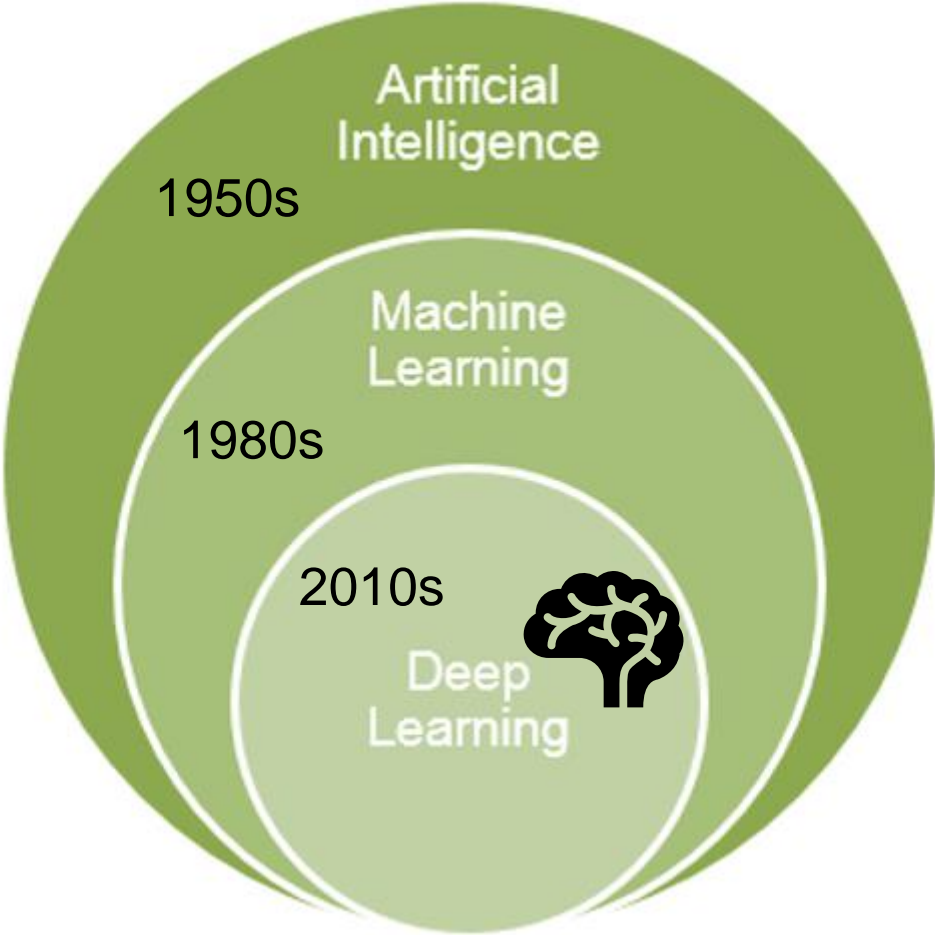


Machine Learning



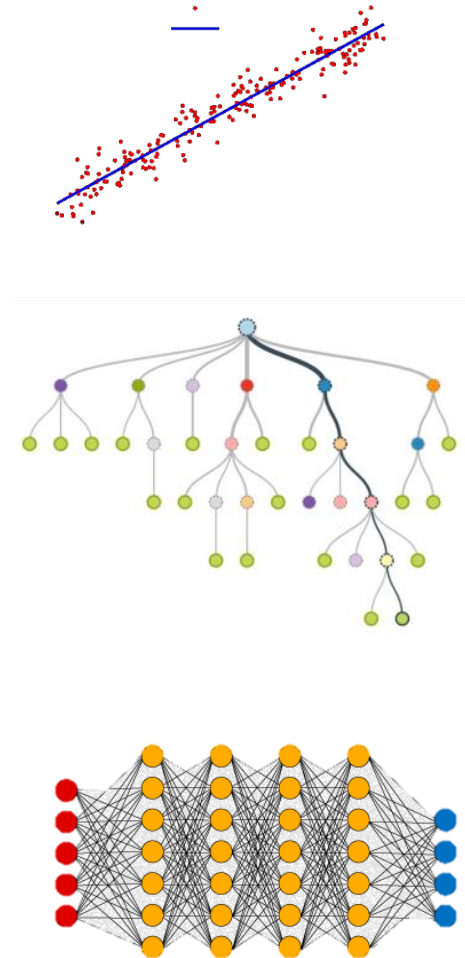
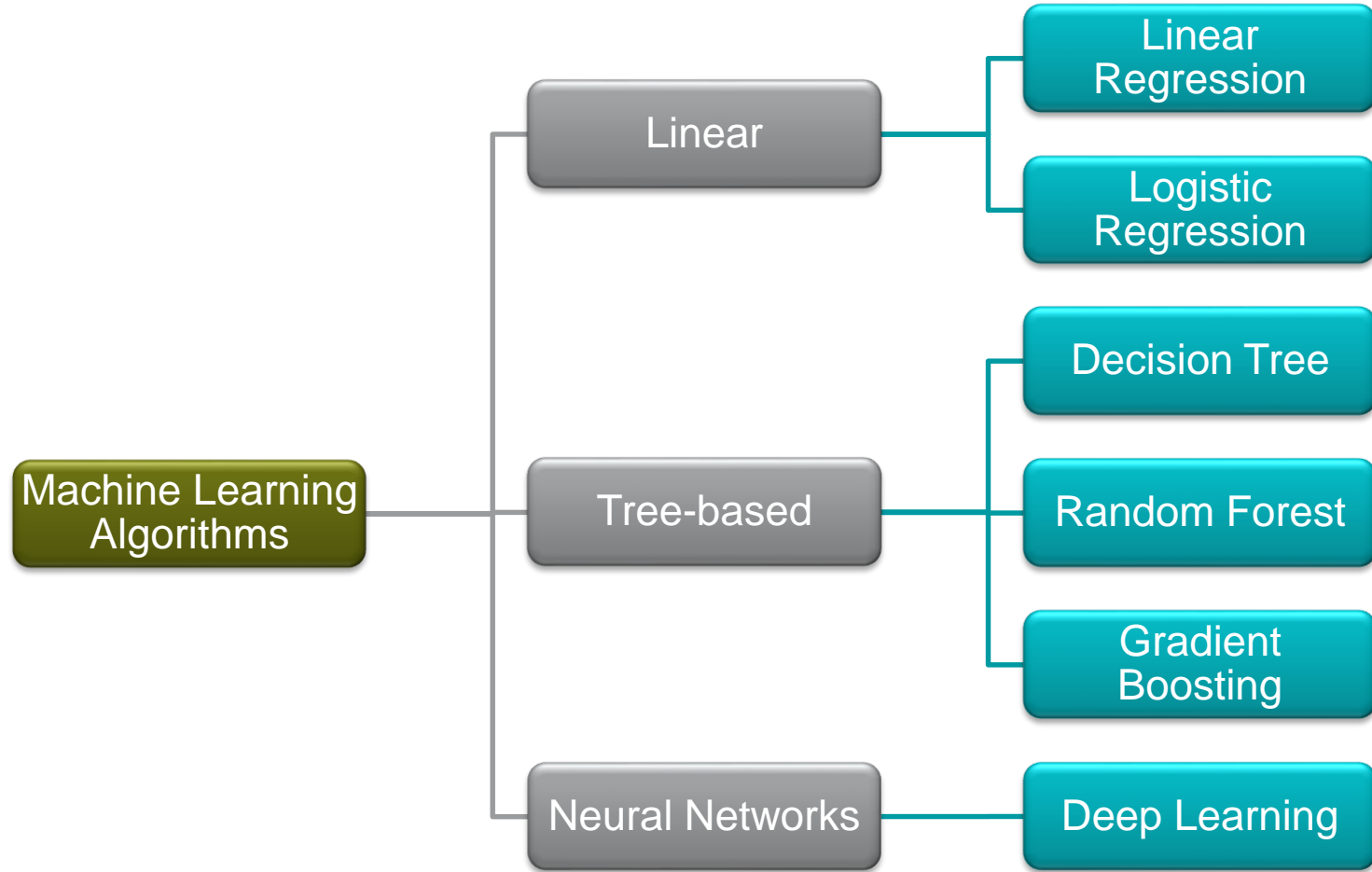
K Means oder ISODATA
Bayesian Networks

Deep Learning



DNNs - Deep Neural Networks

Machine Learning Algorithmen



Wie funktioniert Machine Learning?

Train



Classify



Machine Learning packages



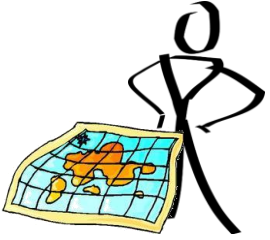
Caffe

The word 'Caffe' is written in a large, red, serif font.

theano

The word 'theano' is written in a large, blue, sans-serif font.

Machine Learning in der Geospatial Welt?



Die meisten Machine Learning Bibliotheken sind nicht für die Geospatial-Welt gemacht.



Komplexe Machine Learning Ansätze sind noch in der Forschung und brauchen einen Experten.



Eigene Abläufe und Lösungen entwickeln ist nicht einfach.

Machine learning-Bedarf in der Geospatial Welt

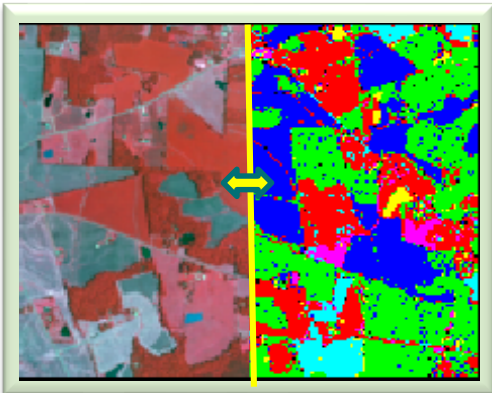


Image Classification



Change
Detection



Feature
Extraction



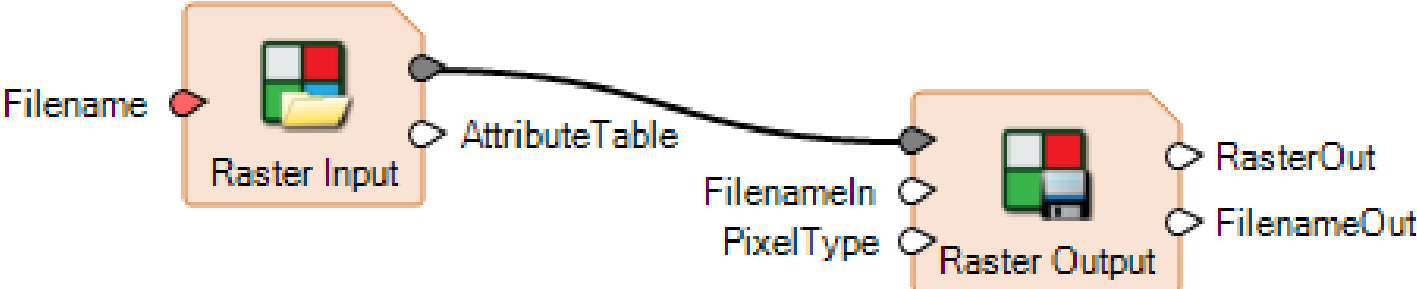
Prediction



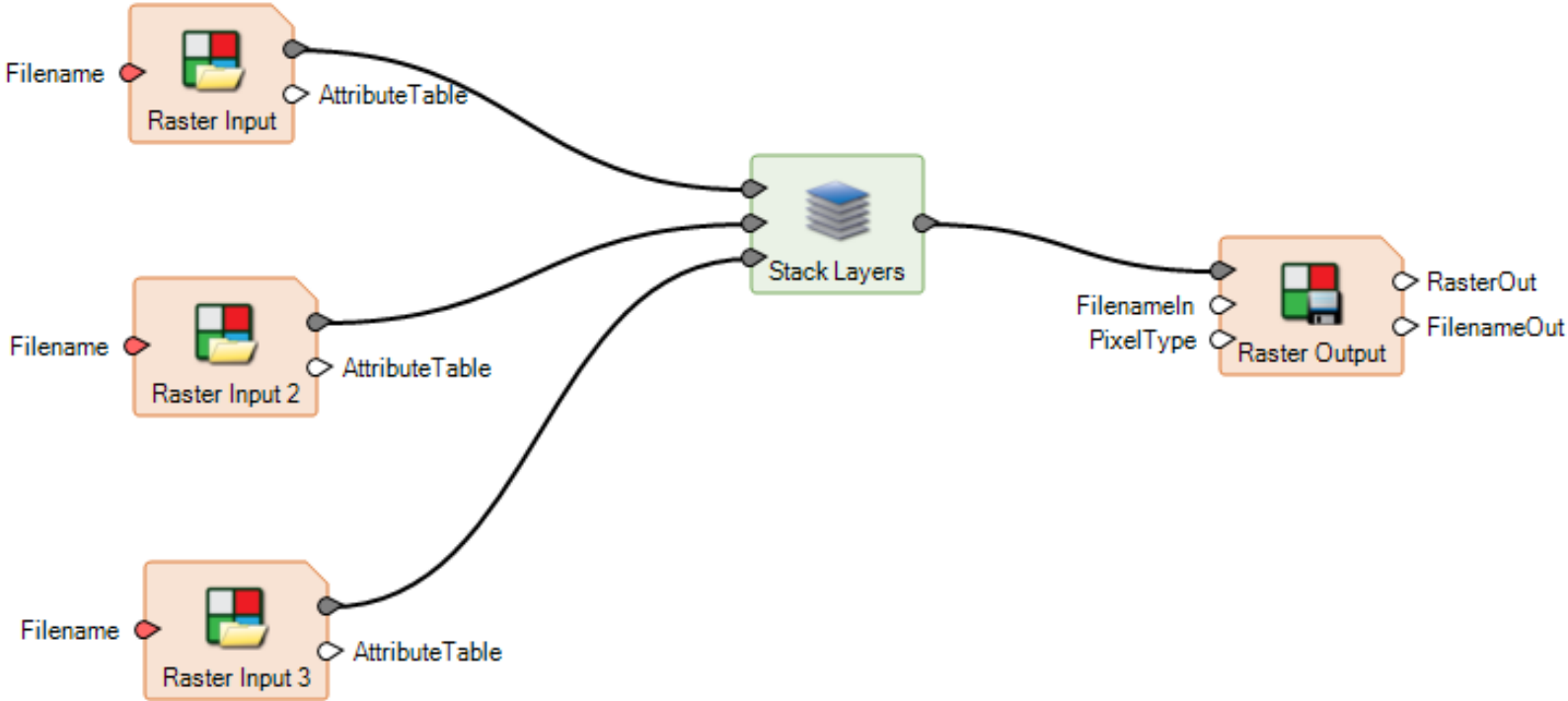
Machine Learning mit dem Spatial Modeler



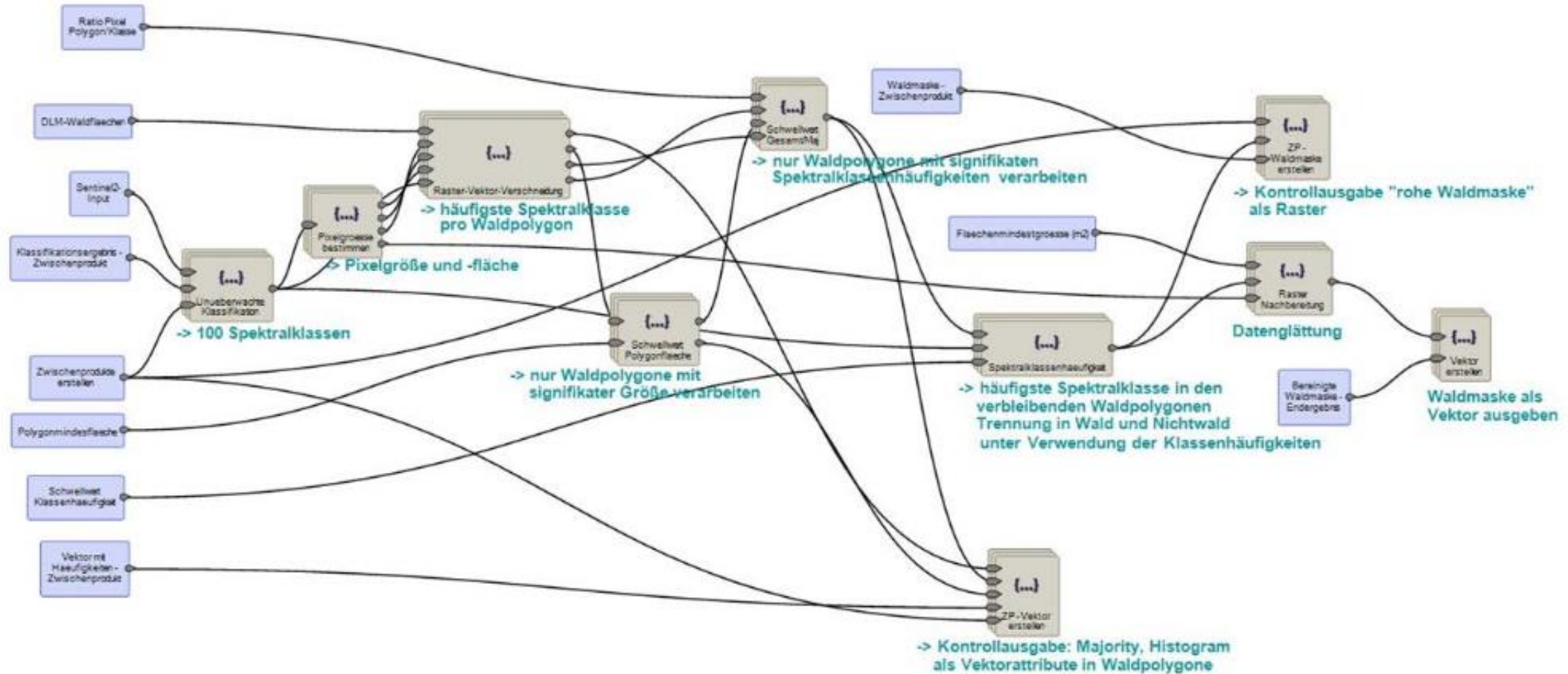
Einfachstes Spatial Model



Layer Stack im Spatial Model



Komplexes Spatial Model



F. Spitzer, GEOSYSTEMS GmbH 2017

Wo findet sich der Spatial Modeler?

- IMAGINE Professional
- IMAGINE Essentials (Ausführen von Modellen)
- GeoMedia Professional
- ERDAS APOLLO Professional
- M.App Studio
- M.App Enterprise

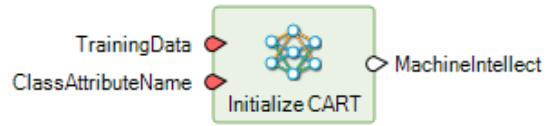


Verwendete OpenSource-Bibliotheken

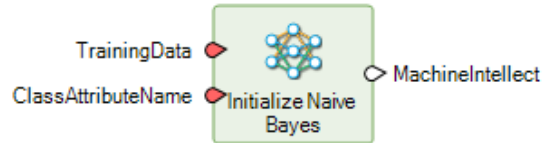


Caffe

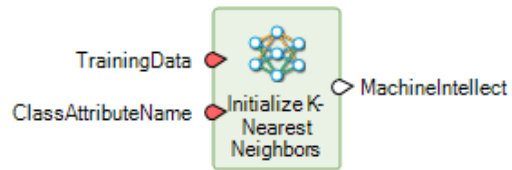
Machine Learning Operatoren im Spatial Modeler



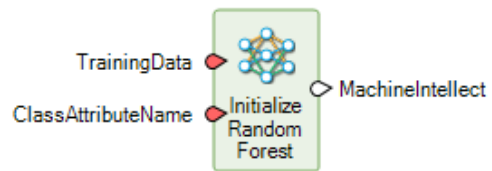
Classification and Regression Trees



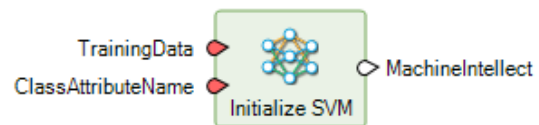
Naive Bayes



K-Nearest Neighbors

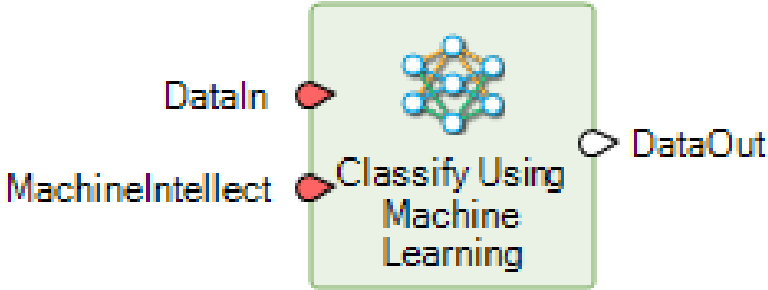


Random Forests



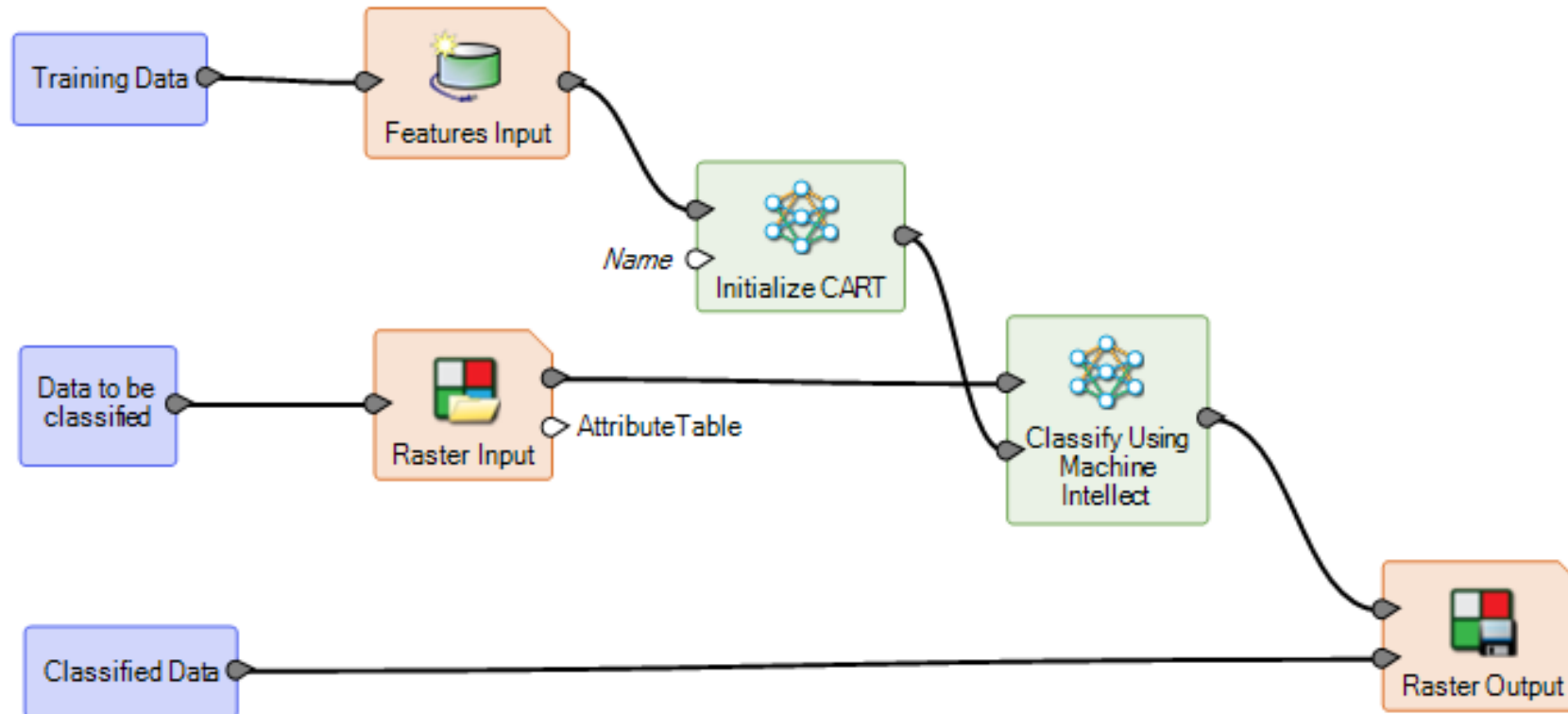
Support Vector Machines

Classify Using....



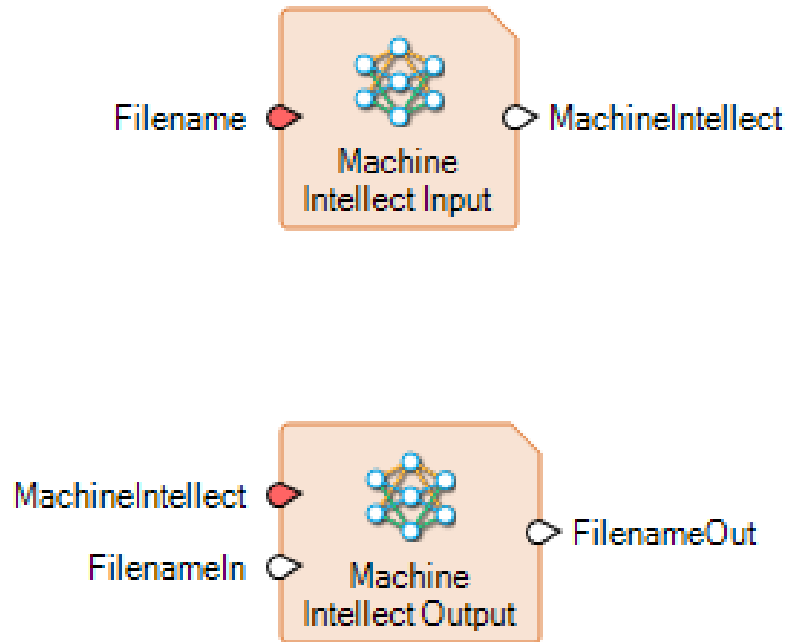
Unsupervised Classifier

Beispiel-Model für den CART-Algorithmus

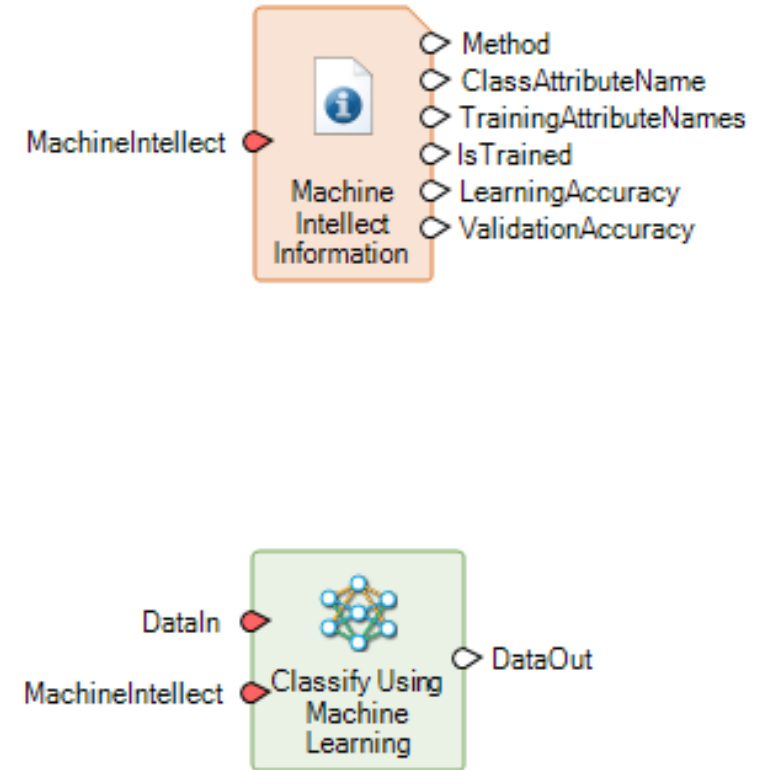


Machine Intellect

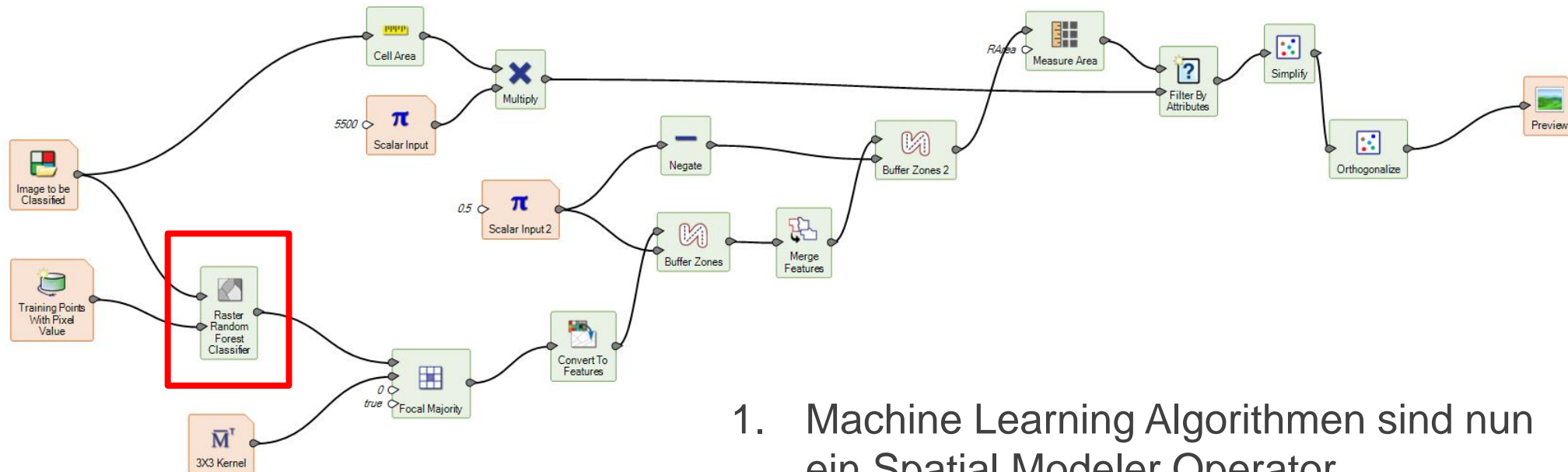
Gut beschrifteten!



Machine Intellect

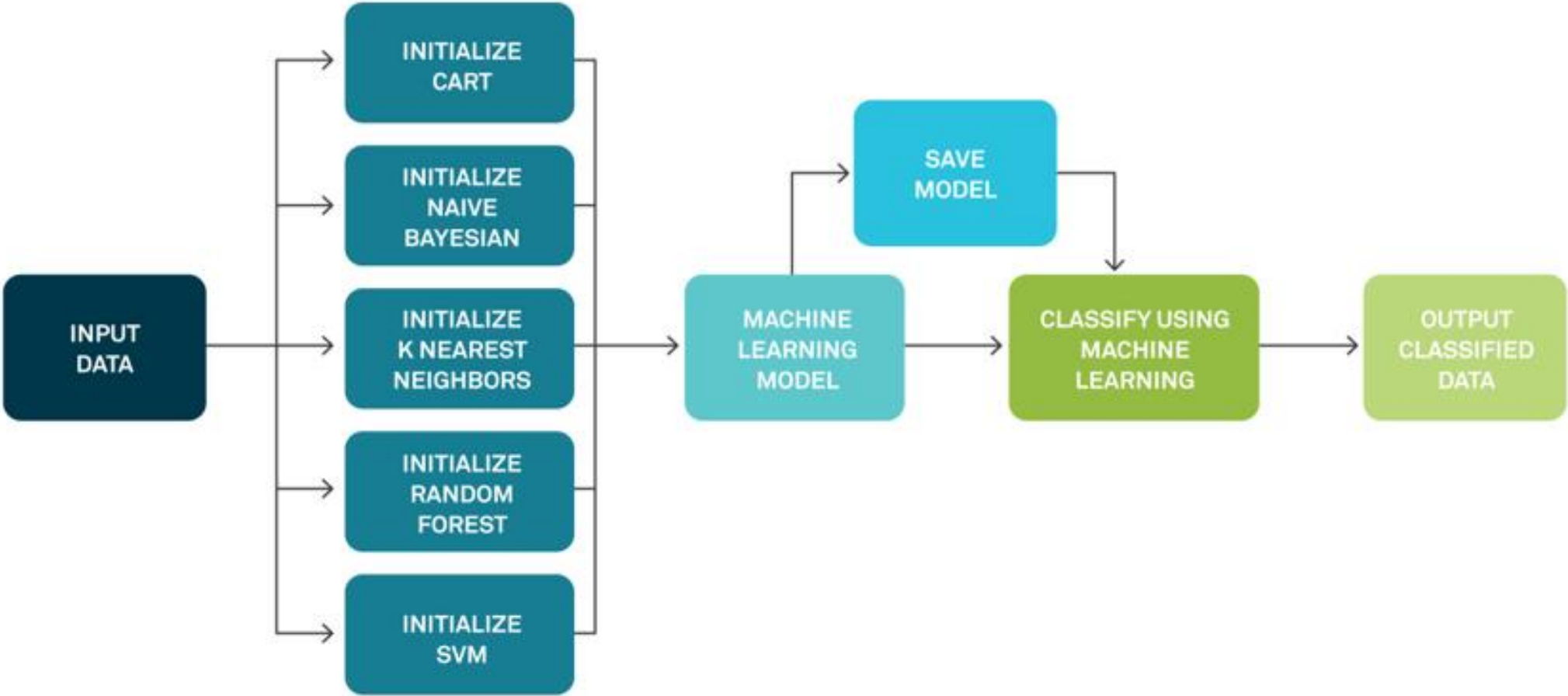


Machine Learning mit dem Hexagon Geospatial Spatial Modeler



1. Machine Learning Algorithmen sind nun ein Spatial Modeler Operator.
2. Kombination von Machine Learning mit den Operatoren des Spatial Modelers.
3. Einbauen/Integrieren von Machine Learning Algorithmen mit vorhandenen Workflows.

Ablaufschema Machine Learning in IMAGINE



Phasen eines Machine Learning Projekts

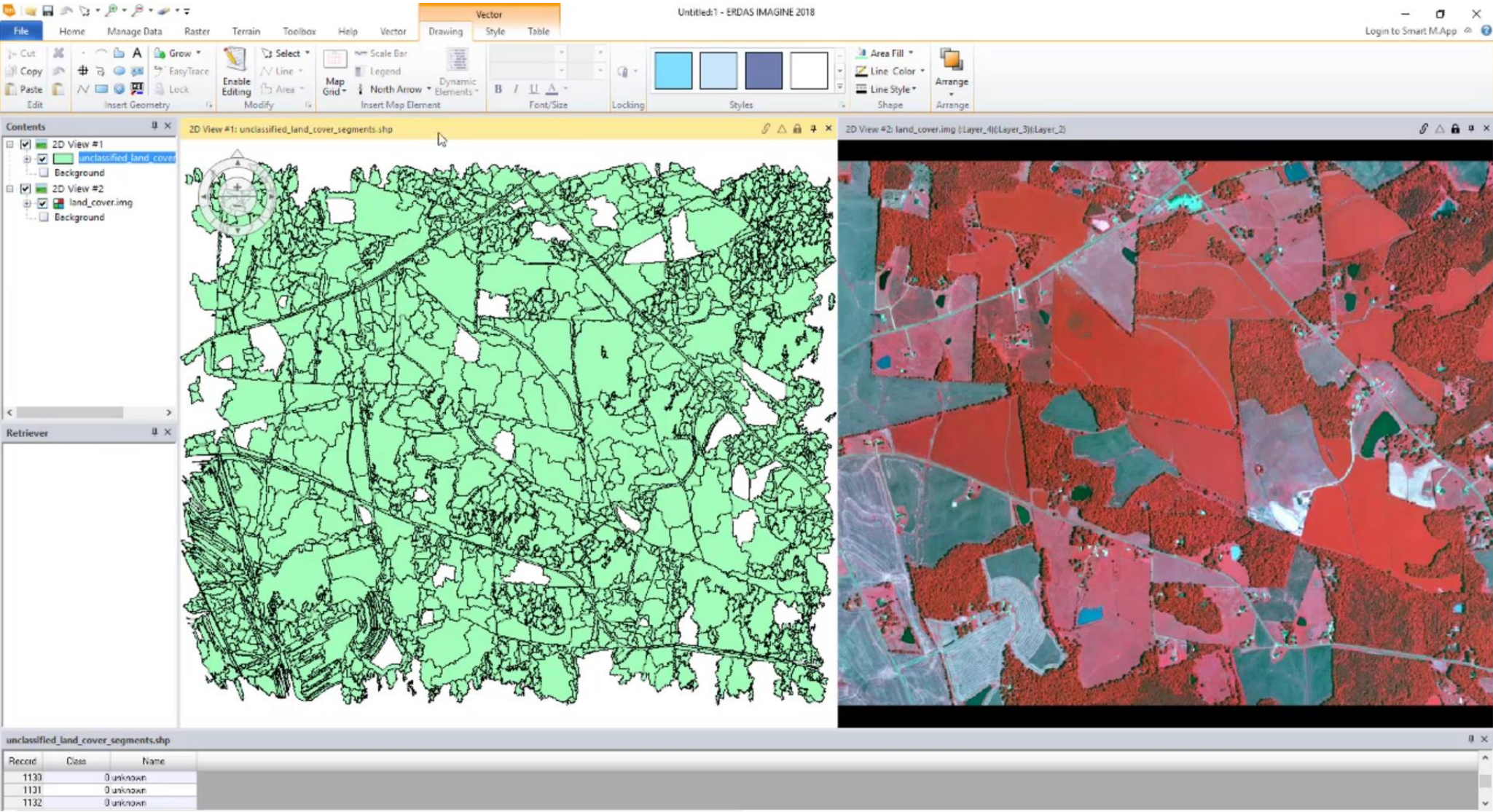
- Vorbereitung der Trainingsdaten
- Auswahl des Machine Learning Modells
- Modell trainieren
- Testen und Validieren
- Anwenden



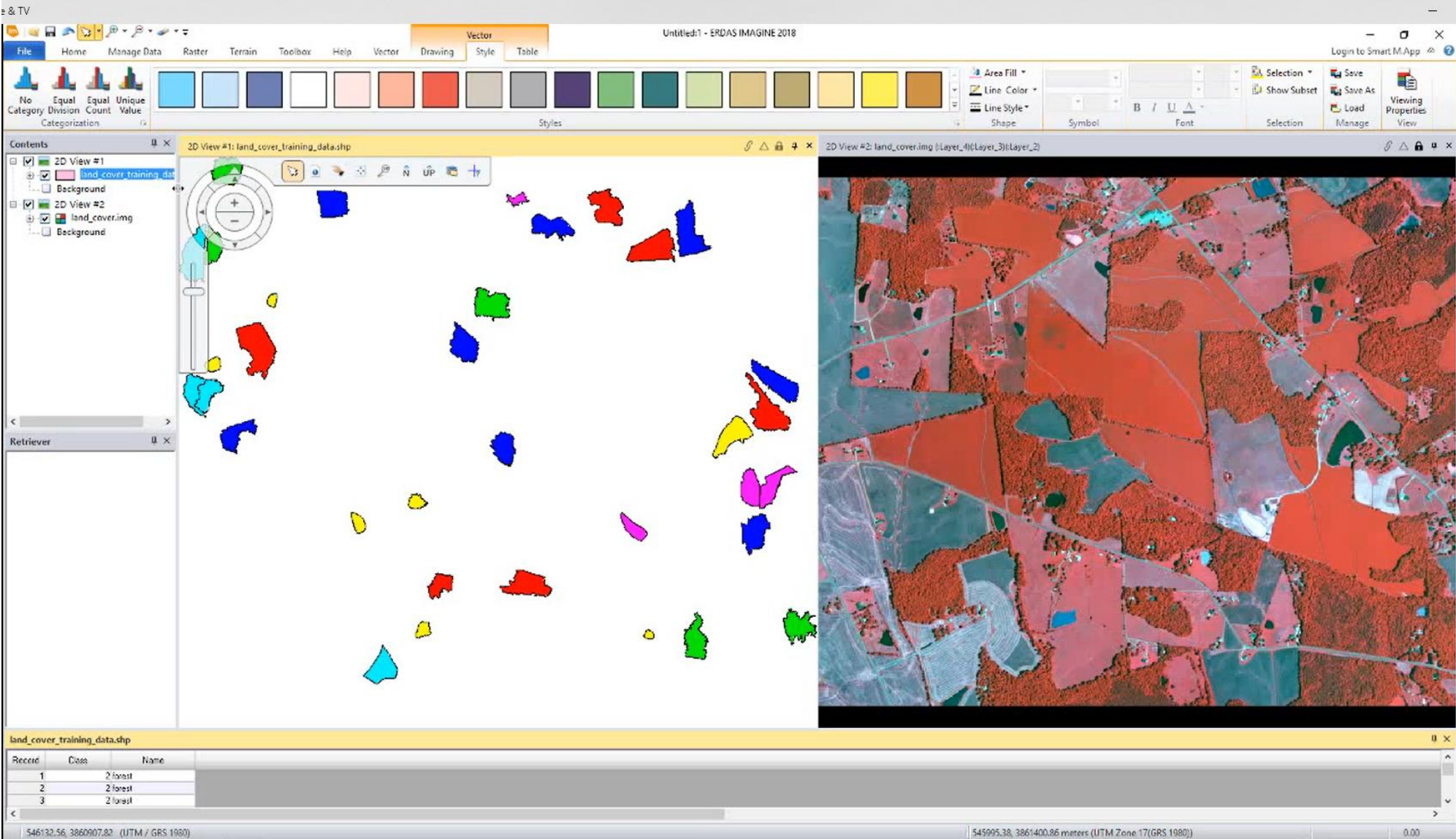
Machine Learning Beispiel - Vektorklassifikation



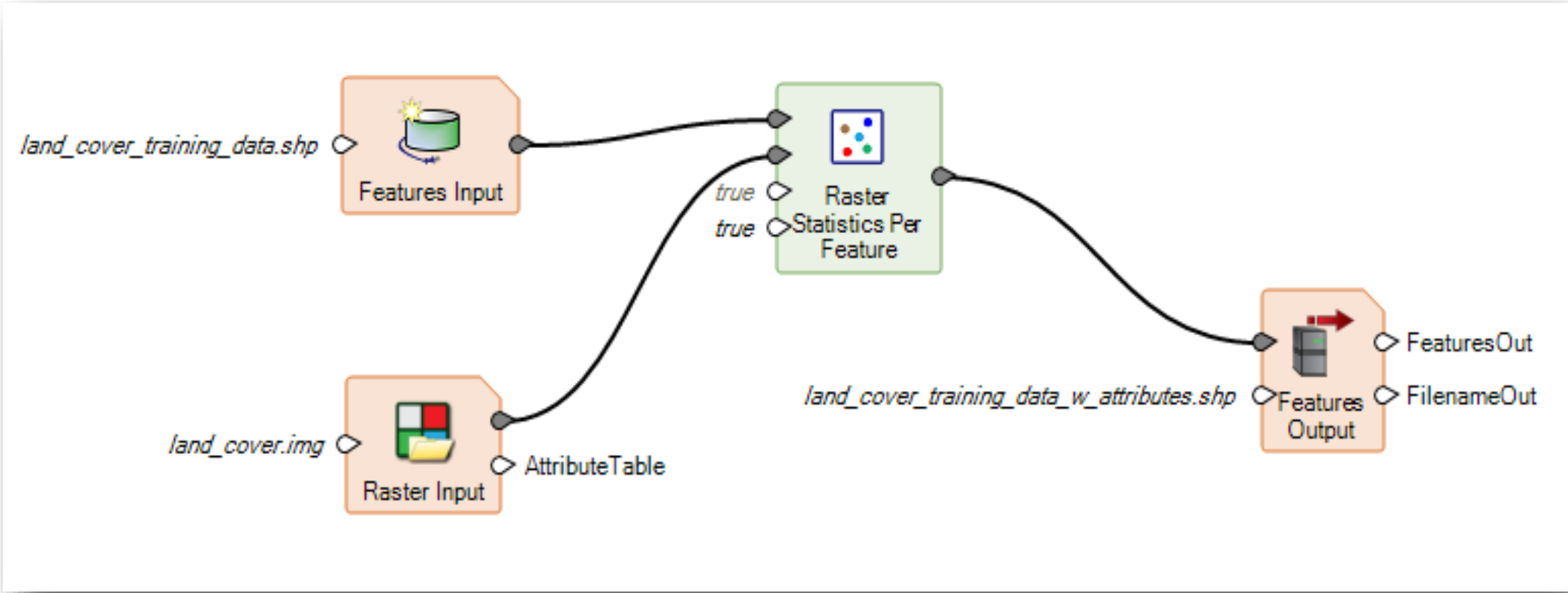
Zu klassifizierende Vektoren und Rasterdatensatz für das Training



Vektor-Trainingsgebiete



Trainingsdaten aufbereiten – Statistik als neues Attribut

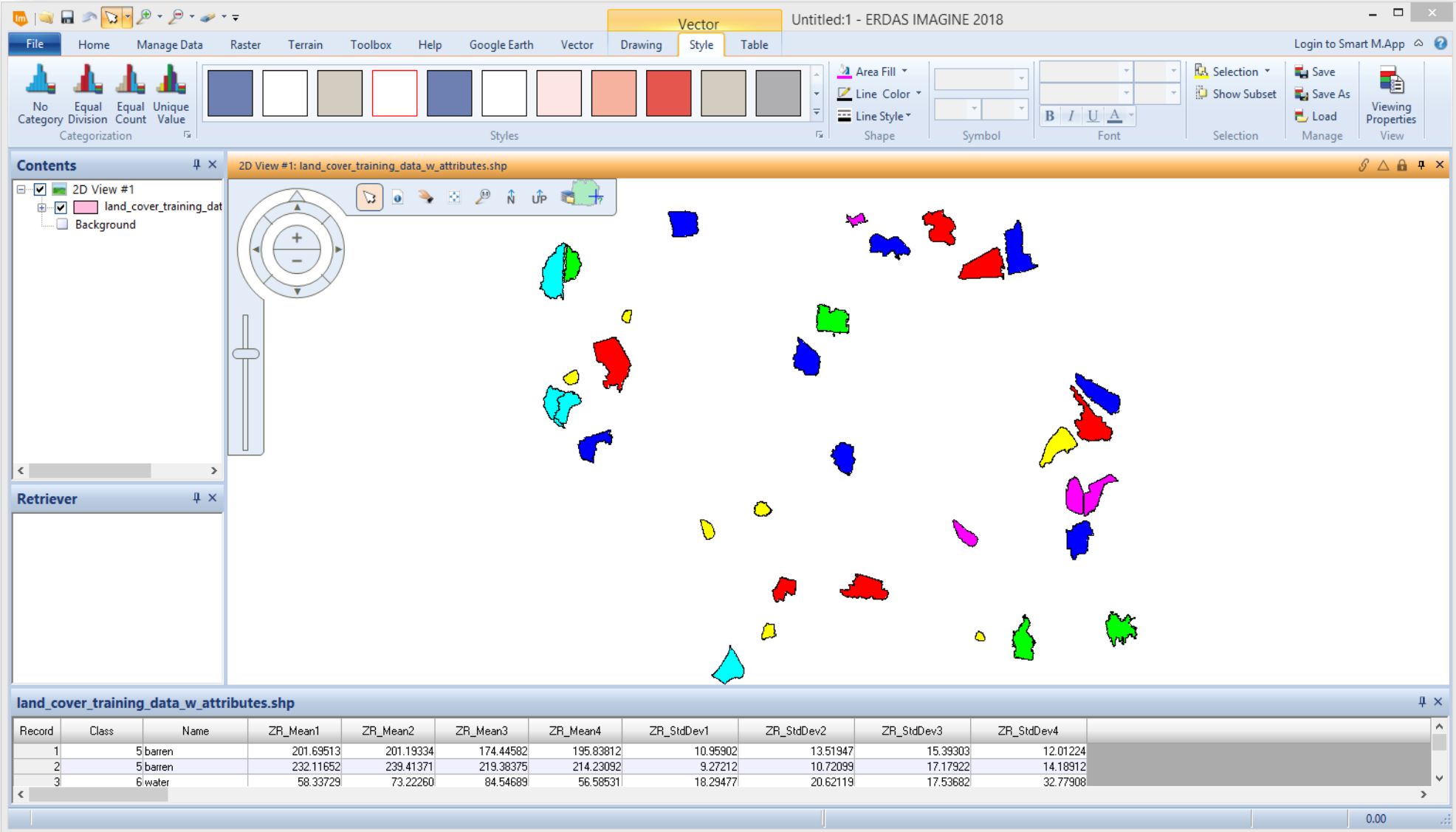


Trainingsdaten aufbereiten – Mean + StdDev

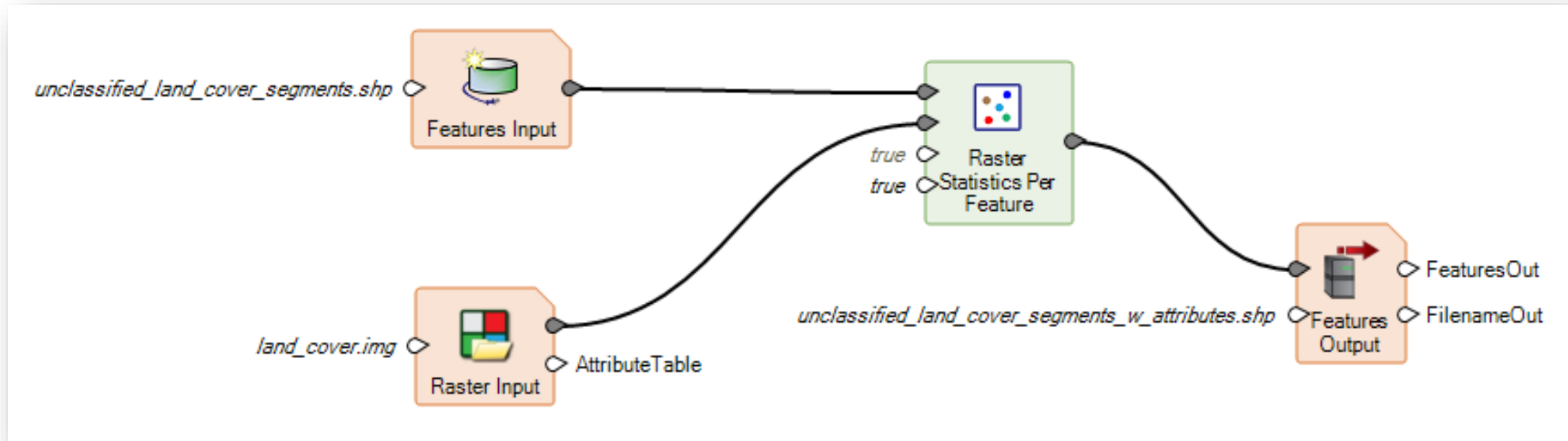
The diagram illustrates a GIS workflow for preparing training data. It consists of three main tools: 'Features Input', 'Raster Input', and 'Statistics'. The 'Features Input' tool takes 'land_cover_training_data.shp' as input. The 'Raster Input' tool takes 'land_cover.img' as input. Both tools feed into the 'Statistics' tool. The 'Statistics' tool has 'true' checked for 'Raster' and 'Statistics Features'. The 'Properties' window for the 'Statistics' tool is open, showing a list of statistical parameters with 'ComputeStdDev' checked.

Show	Name	Value	Objects Supported	Required
<input checked="" type="checkbox"/>	Raster		IMAGINE.Raster	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	ComputeMean	true	IMAGINE.Boot	
	MeanAttribute	"Mean"	IMAGINE.String	
	ComputeMax	false	IMAGINE.Boot	
	MaxAttribute	"Max"	IMAGINE.String	
	ComputeMin	false	IMAGINE.Boot	
	MinAttribute	"Min"	IMAGINE.String	
	ComputeMode	false	IMAGINE.Boot	
	MedianAttribute	"Median"	IMAGINE.String	
	ComputeMajority	false	IMAGINE.Boot	
	ModeAttribute	"Mode"	IMAGINE.String	
<input checked="" type="checkbox"/>	ComputeStdDev	true	IMAGINE.Boot	
	StdDevAttribute	"StdDev"	IMAGINE.String	
	ComputeDiversity	false	IMAGINE.Boot	
	DiversityAttribute	"Diversity"	IMAGINE.String	
	ComputeMajority	false	IMAGINE.Boot	
	MajorityAttribute	"Majority"	IMAGINE.String	
	ComputeMinority	false	IMAGINE.Boot	
	MinorityAttribute	"Minority"	IMAGINE.String	
	ComputeSum	false	IMAGINE.Boot	
	SumAttribute	"Sum"	IMAGINE.String	
	ComputeCount	false	IMAGINE.Boot	
	CountAttribute	"Count"	IMAGINE.String	
	AttributeNan	"ZR_"	IMAGINE.String	
<input checked="" type="checkbox"/>	FeaturesOut		IMAGINE.Features	

Trainingsdaten aufbereiten – Mean + StdDev



Eingangsdaten aufbereiten – Mean + StdDev



Eingangsdaten aufbereiten – Mean + StdDev wurden berechnet

The screenshot displays the ERDAS IMAGINE 2018 software interface. The main window shows a 2D view of a map titled "2D View #1: unclassified_land_cover_segments_w_attributes.shp". The map displays a complex network of land cover segments, primarily colored in shades of green, with some white areas. A north arrow is visible in the top-left corner of the map area.

The interface includes a menu bar at the top with options like File, Home, Manage Data, Raster, Terrain, Toolbox, Help, Google Earth, Vector, Drawing, Style, and Table. Below the menu bar is a toolbar with various icons for map manipulation and data processing. The "Style" tab is currently active, showing a color palette and various styling options.

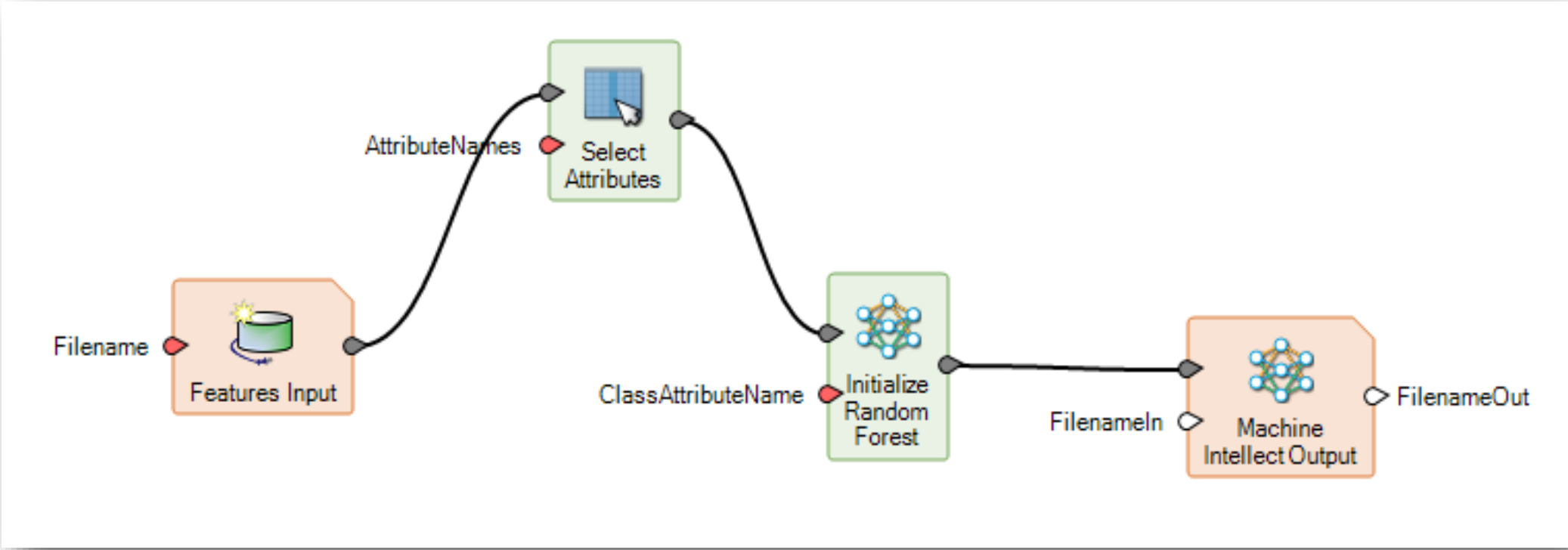
On the left side, there is a "Contents" panel showing the map's structure, including "2D View #1", "unclassified_land_cover", and "Background". Below it is a "Retriever" panel.

At the bottom of the interface, a data table is displayed for the file "unclassified_land_cover_segments_w_attributes.shp". The table has 11 columns: Record, Class, Name, ZR_Mean1, ZR_Mean2, ZR_Mean3, ZR_Mean4, ZR_StdDev1, ZR_StdDev2, ZR_StdDev3, and ZR_StdDev4. The table contains three rows of data.

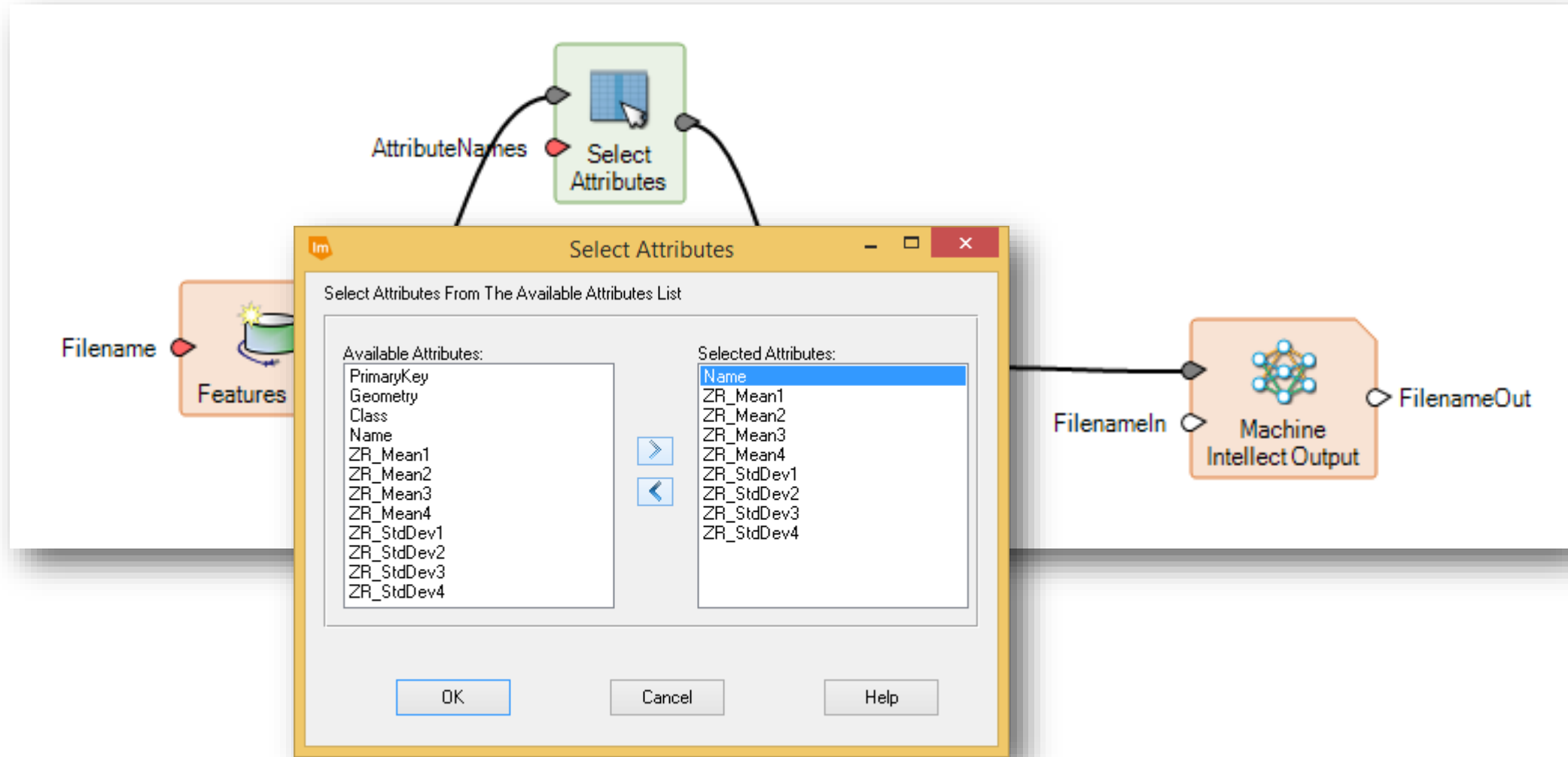
Record	Class	Name	ZR_Mean1	ZR_Mean2	ZR_Mean3	ZR_Mean4	ZR_StdDev1	ZR_StdDev2	ZR_StdDev3	ZR_StdDev4
1	0 unknown		82.24911	91.43802	93.29280	130.10744	25.92101	30.02571	27.85528	42.97794
2	0 unknown		142.48498	136.62006	128.14080	139.60492	27.19376	29.41844	28.08557	31.32726
3	0 unknown		138.81053	147.44418	137.56604	153.70755	29.28983	36.01619	35.26889	39.08152

The status bar at the bottom shows the coordinates "547743.13, 3860000.67 (UTM / GRS 1980)" and the scale "0.00".

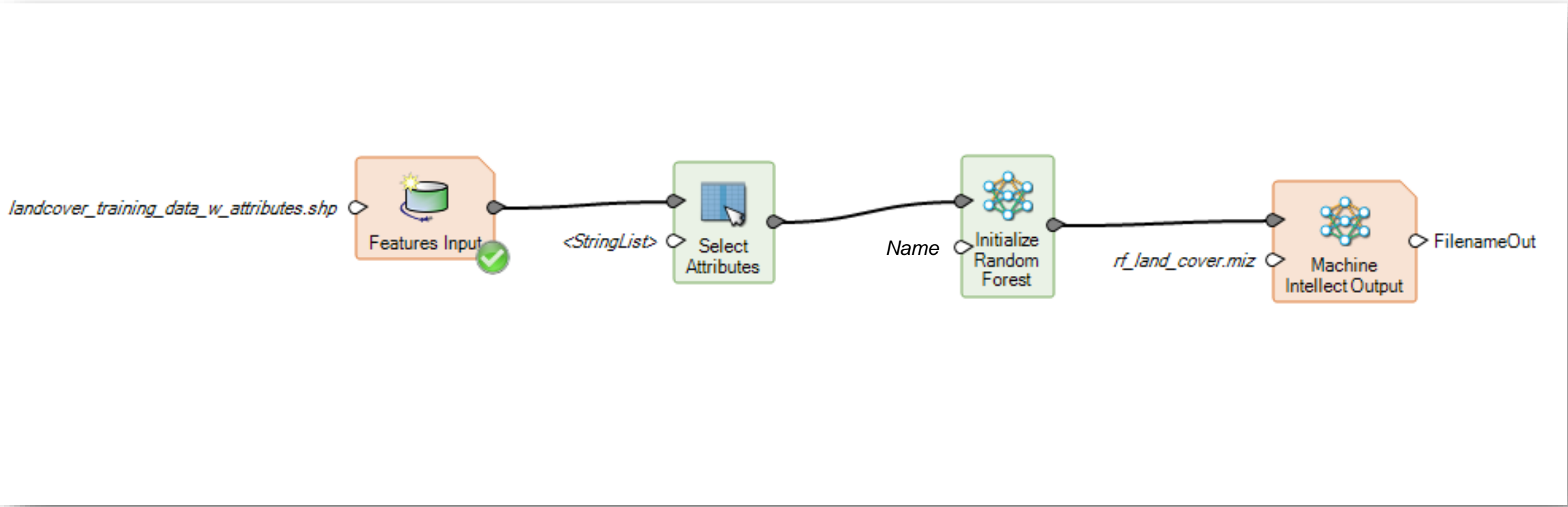
Random Forest Algorithmus trainieren – Initialize



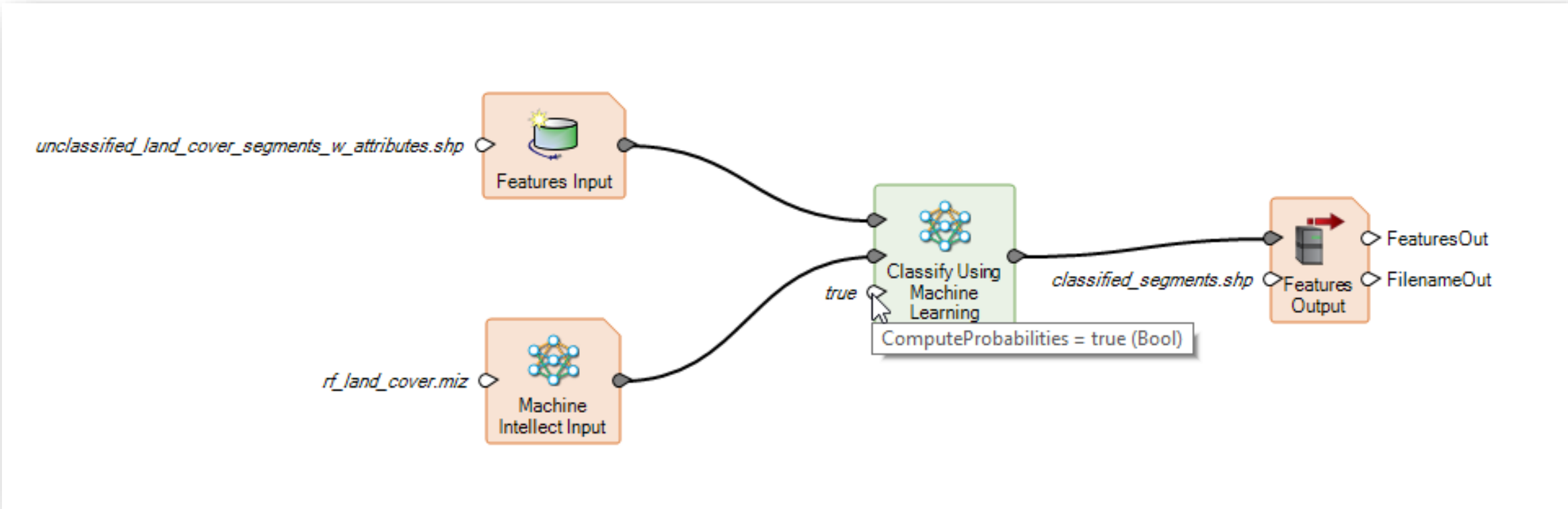
Random Forest Algorithmus trainieren – Select Attributes



Random Forest Algorithm – Ausgabe des Machine Intellect



Mit trainiertem Machine Intellect klassifizieren

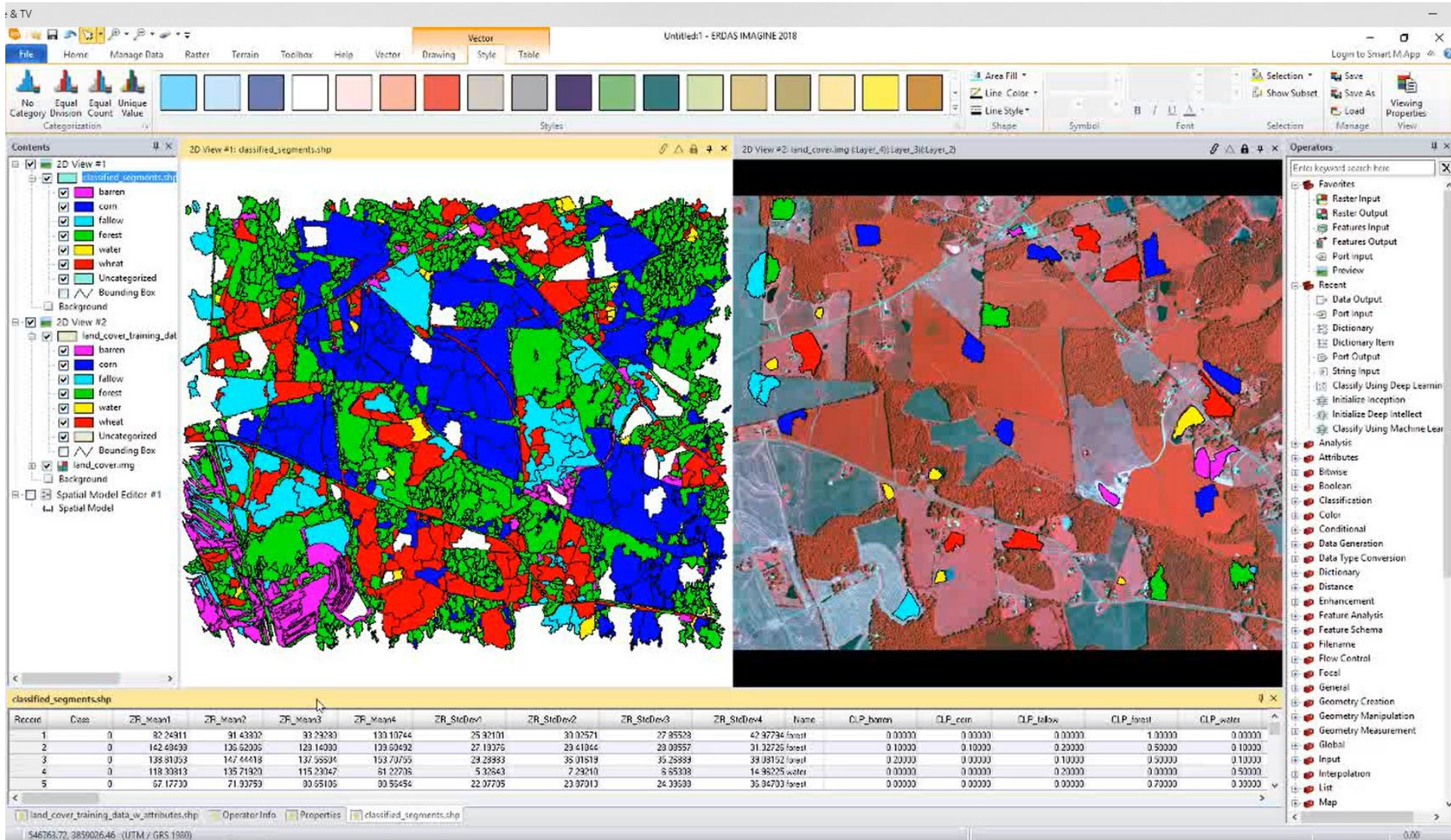


Ergebnisanalyse

The screenshot displays the ArcGIS Desktop interface. The main window shows a map with a land cover classification. The 'Contents' pane on the left lists the layers, including 'classified_segments.shp'. The 'Retriever' pane shows the project structure. The 'Properties' pane on the right is empty. The attribute table at the bottom shows the following data:

Record	Class	ZR_Mean1	ZR_Mean2	ZR_Mean3	ZR_Mean4	ZR_StdDev1	ZR_StdDev2	ZR_StdDev3	ZR_StdDev4	Name	CLP_barren	CLP_corn	CLP_fallow	CLP_forest	CLP_water	CLP_wheat
1	0	103.25812	122.16721	112.84578	170.31656	21.32621	23.94401	23.20496	28.8187	forest	0.00000	0.00000	0.00000	0.70000	0.10000	0.20000
2	0	63.60996	72.79253	87.32365	104.84647	9.03879	12.19989	13.47078	29.4094	corn	0.00000	0.40000	0.00000	0.10000	0.40000	0.10000
3	0	185.70923	181.81139	152.23641	179.30059	21.98282	29.49878	31.93382	28.6770	barren	0.60000	0.00000	0.00000	0.40000	0.00000	0.00000
4	0	81.62014	98.96387	99.48963	198.24619	21.11278	19.90842	14.12651	13.8895	corn	0.00000	0.60000	0.00000	0.30000	0.10000	0.00000
5	0	117.11615	130.56020	115.95397	171.26598	25.94981	26.91702	21.79776	29.7149	forest	0.00000	0.00000	0.00000	0.60000	0.10000	0.30000
6	0	147.67080	160.22504	149.37345	141.76147	28.94417	33.52278	35.70513	37.1183	forest	0.20000	0.00000	0.20000	0.50000	0.00000	0.10000
7	0	102.33784	123.39205	107.79577	183.31549	11.55209	13.75203	10.97977	19.9646	wheat	0.00000	0.20000	0.00000	0.00000	0.30000	0.50000
8	n	73.08666	89.37916	93.24349	147.16097	14.06662	19.38362	18.51607	30.2837	corn	n nnnnn	n nnnnn	n nnnnn	n nnnnn	n nnnnn	n nnnnn

Ergebnis



Herausforderungen

- Overfitting – Modell zu komplex

Modell funktioniert gut auf Trainingsdaten,
läßt sich aber nicht gut generalisieren.

- Modell vereinfachen (weniger Parameter oder einfacheres Modell)
- Reduktion der Eingangsinformation (weniger Attribute)
- Mehr Trainingsdaten

Herausforderungen des Modells

- Overfitting – Modell zu komplex

Modell funktioniert gut auf Trainingsdaten, lässt sich aber nicht gut generalisieren.

- Modell vereinfachen (weniger Parameter oder einfacheres Modell)
- Reduktion der Eingangsinformation (weniger Attribute)
- Mehr Trainingsdaten

- Underfitting – Modell zu einfach

Modell funktioniert auch auf Trainingsdaten nicht gut.

- Einschränkungen untersuchen und verringern
- Komplexeres Modell mit mehr Parametern wählen
- Bessere Trainingsdaten verwenden

Herausforderungen der Trainingsdaten

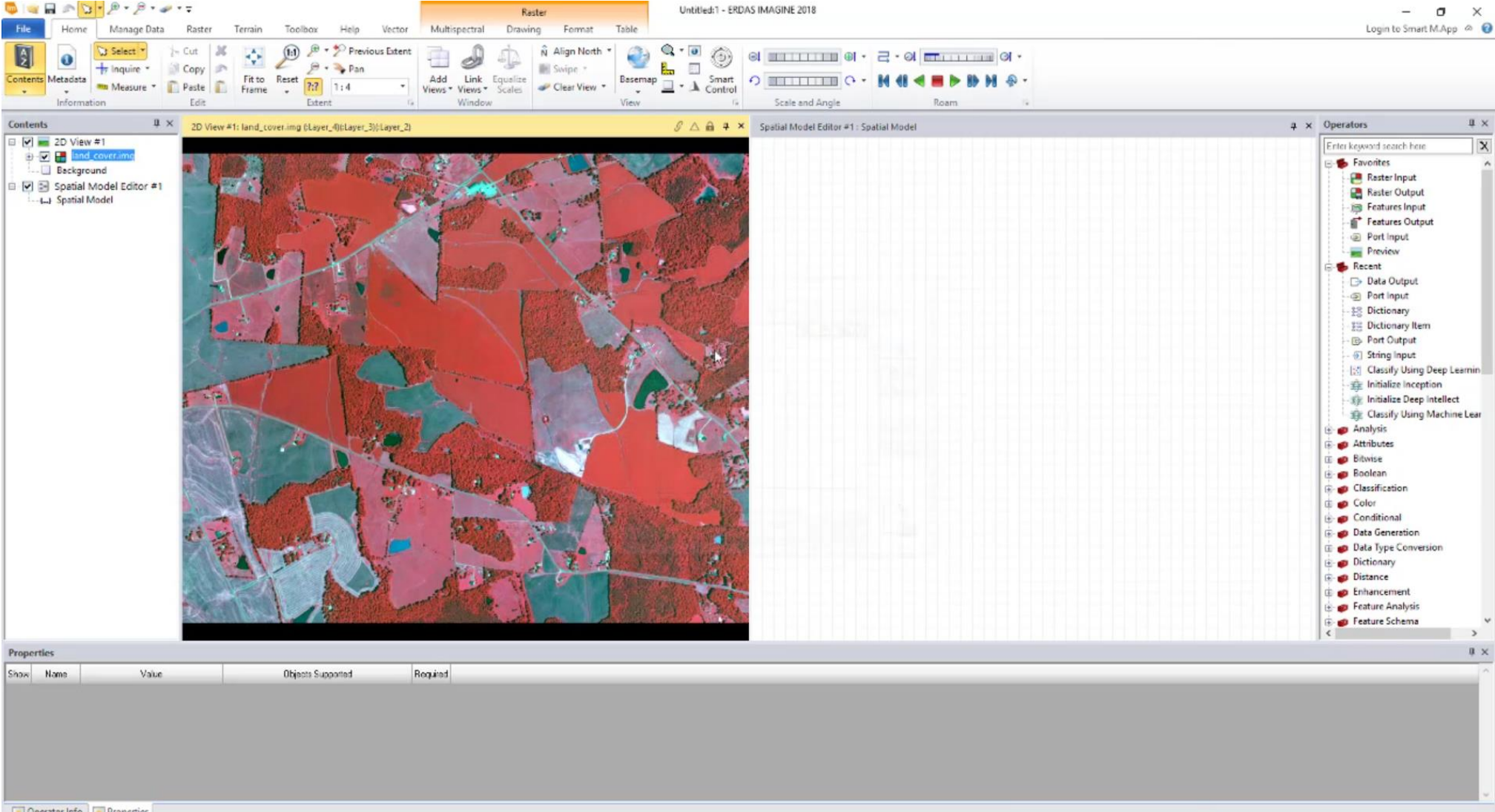
- Ausreichend hohe Quantität
- Repräsentiv
- Gute Qualität
- Ausreichend viel relevante Attribute
- Wenig irrelevante Attribute



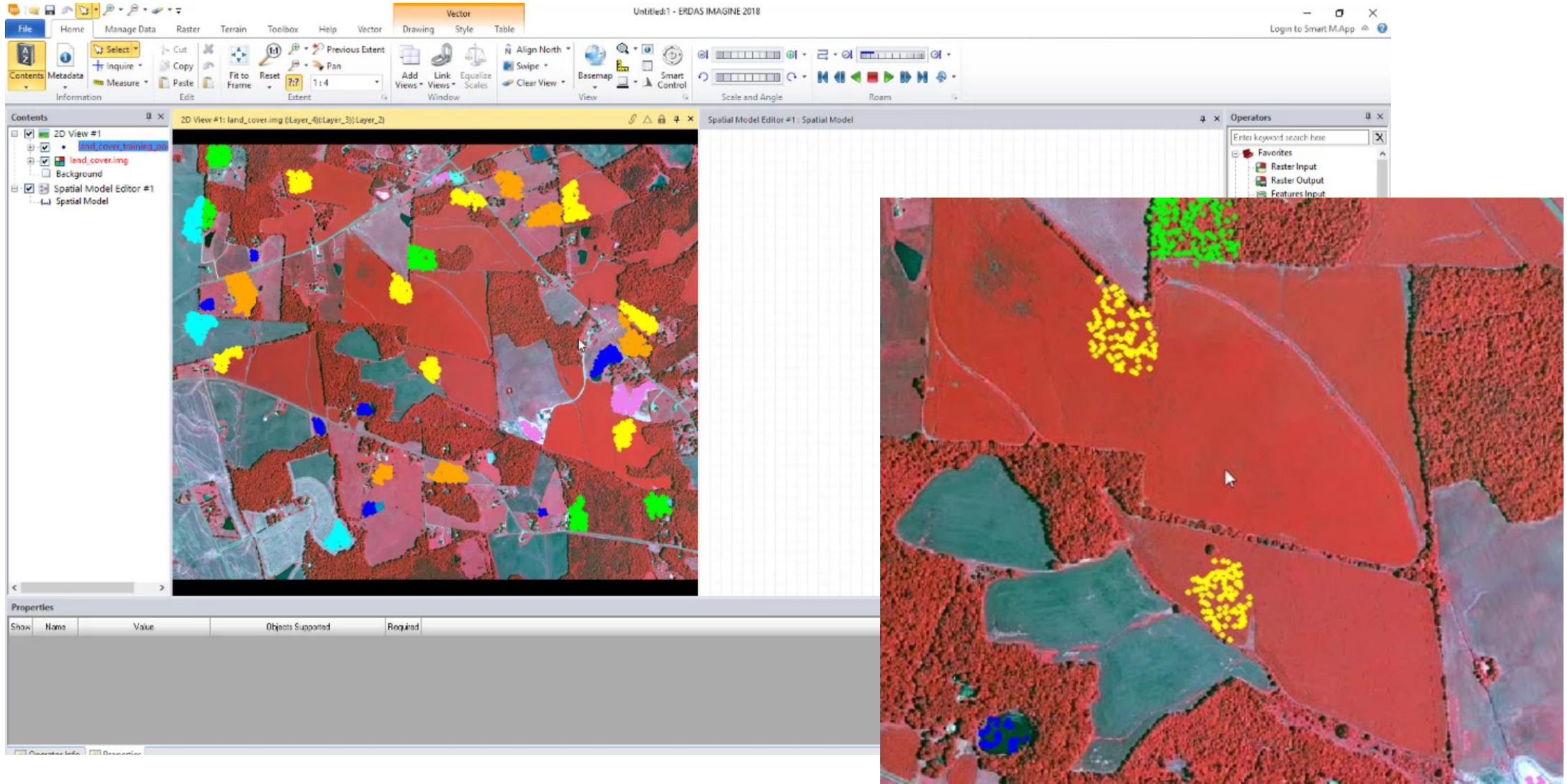
Machine Learning Beispiel - Rasterklassifikation



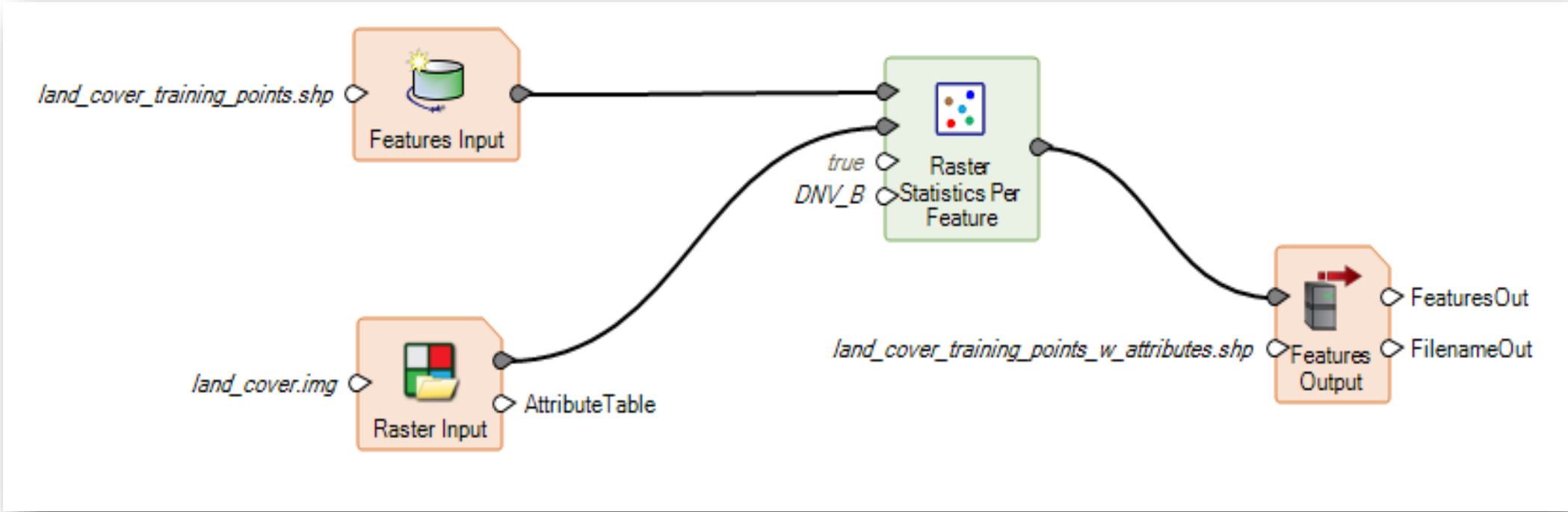
Zu klassifizierendes Rasterbild



Rasterbild mit Trainingsdaten (Punkt-Vektoren)



Trainingsdaten aufbereiten – DN als neues Attribut

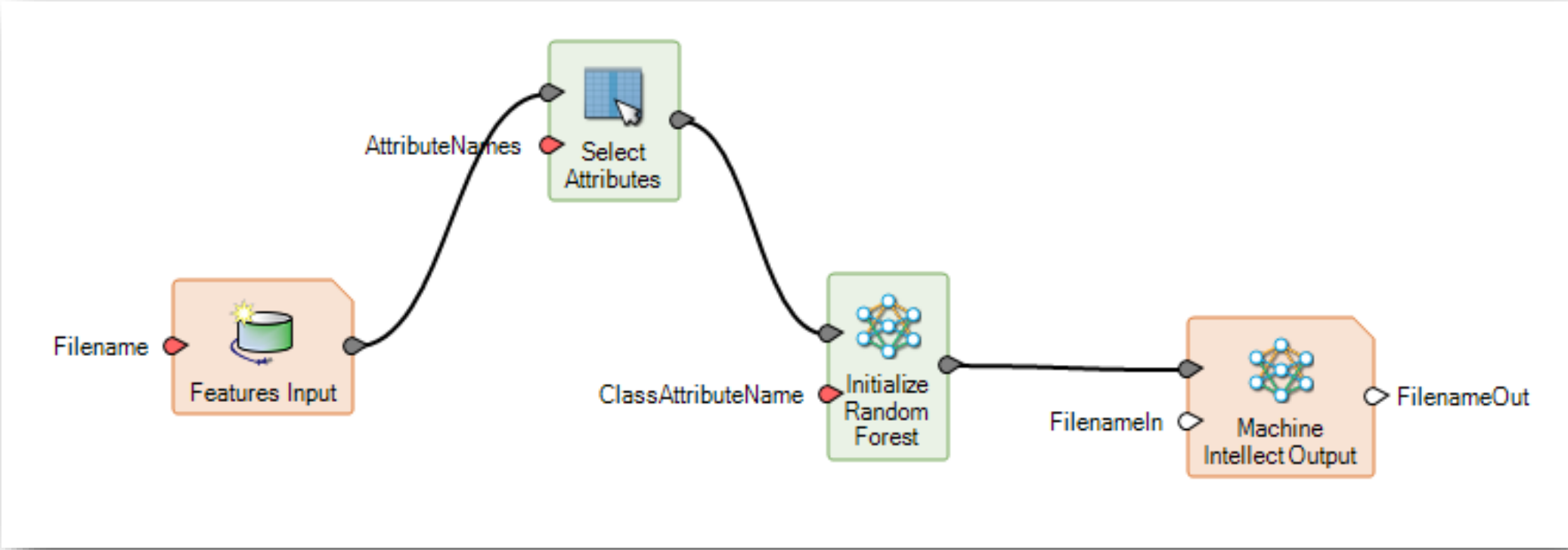


Trainingsdaten aufbereiten – DN Value per Band

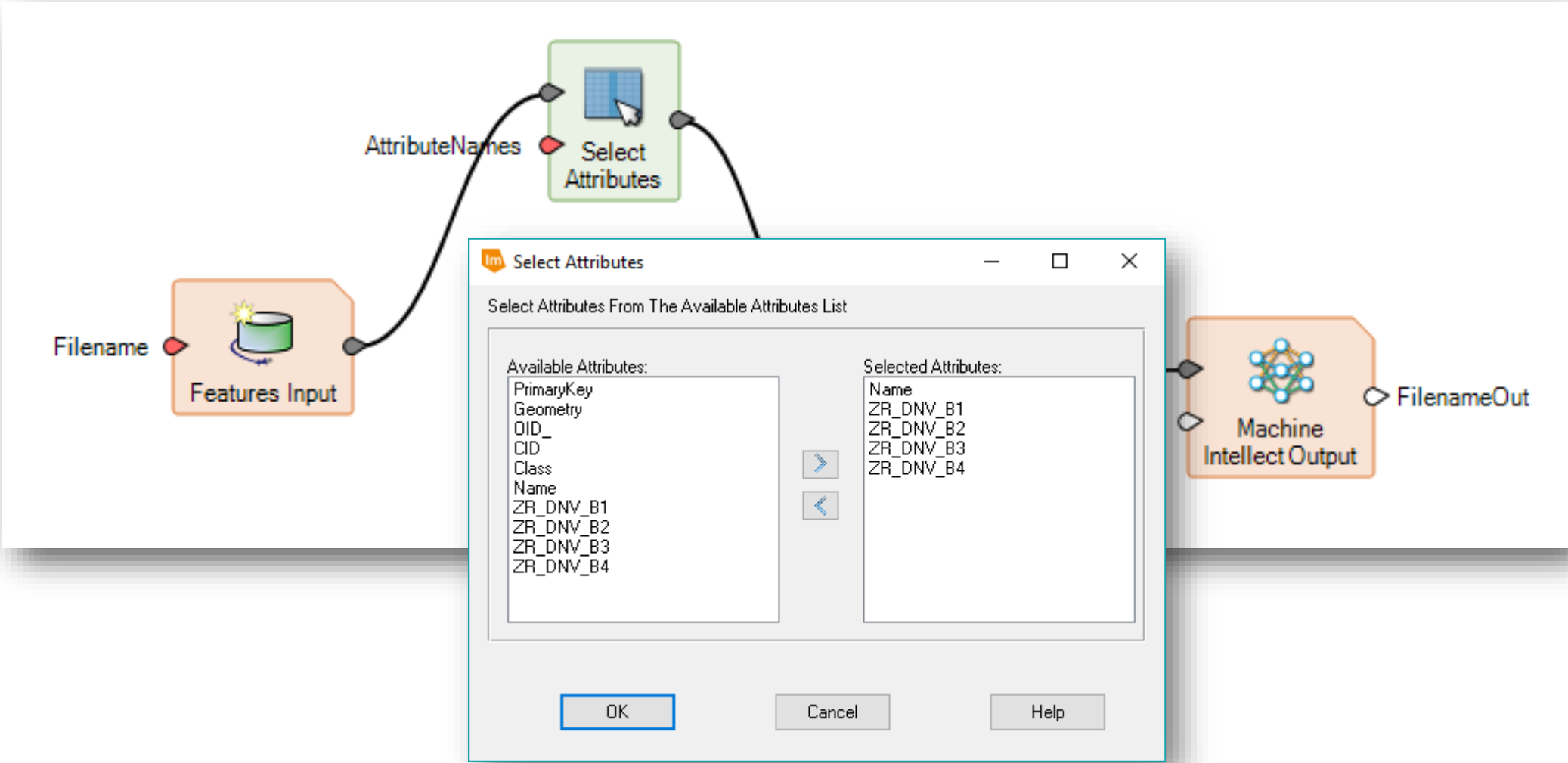
The screenshot displays the ERDAS IMAGINE 2018 interface. The main window shows a 2D view of training points for a land cover dataset, with points colored in various colors (red, blue, green, yellow, cyan, magenta). The interface includes a menu bar (File, Home, Manage Data, Raster, Terrain, Toolbox, Help, Google Earth, Vector, Drawing, Style, Table), a toolbar with various tools, and a Contents pane on the left. The attribute table at the bottom is titled 'land_cover_training_points_w_attributes.shp' and contains the following data:

Record	OID_	CID	Class	Name	ZR_DNV_B1	ZR_DNV_B2	ZR_DNV_B3	ZR_DNV_B4
1	0	13	4 wheat		139.00000	147.00000	124.00000	171.00000
2	0	13	4 wheat		142.00000	148.00000	125.00000	171.00000
3	0	13	4 wheat		132.00000	143.00000	123.00000	185.00000

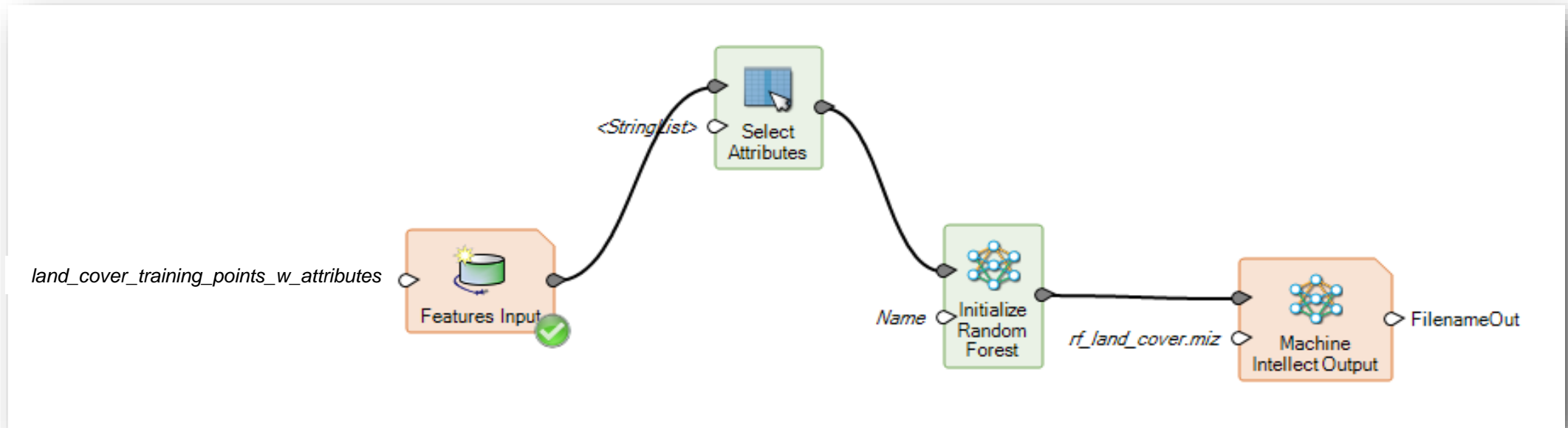
Random Forest Algorithmus trainieren – Initialize



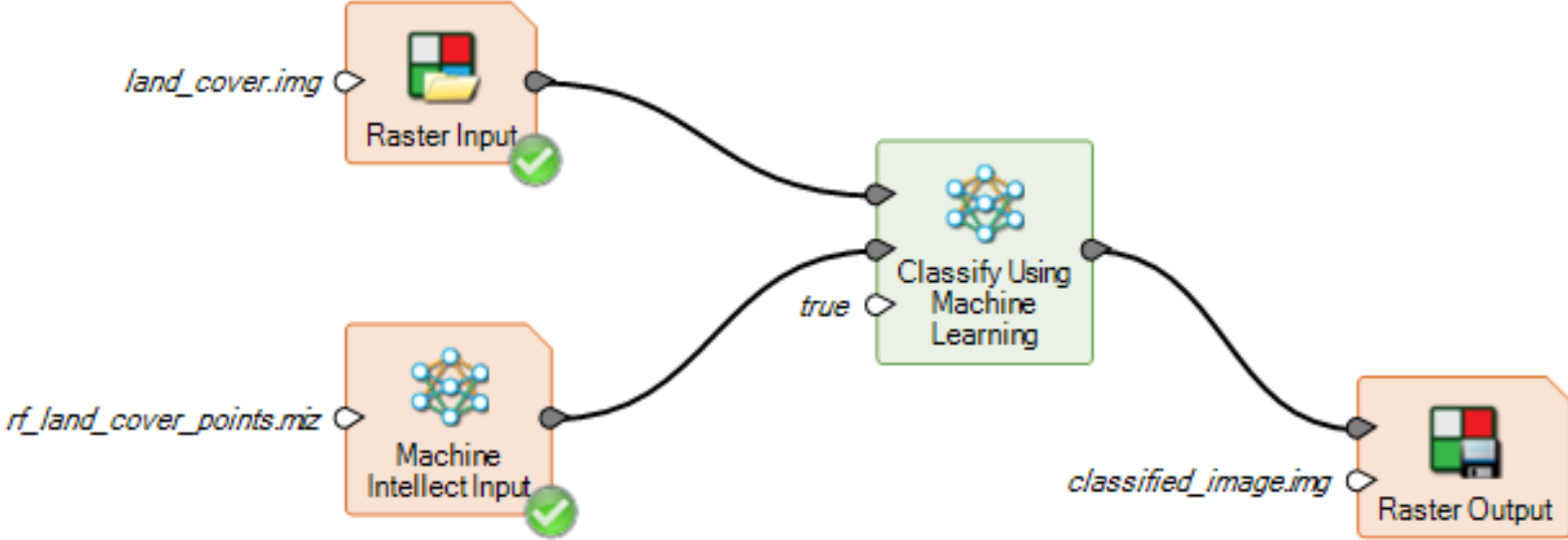
4. Random Forest Algorithmus trainieren – Initialize



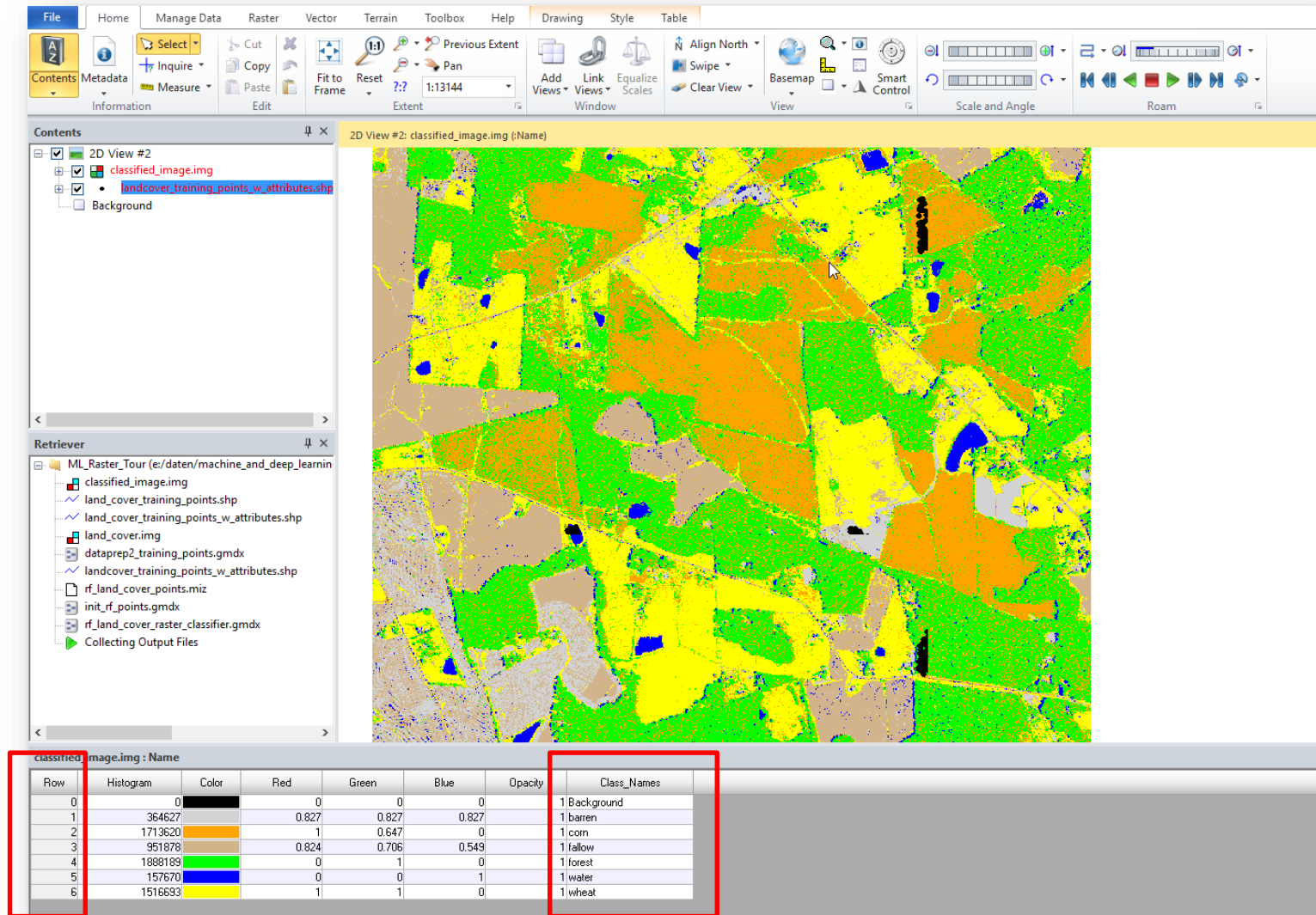
Random Forest Algorithmus – Machine Intellect ausgeben



Mit trainiertem Machine Intellect klassifizieren



Ergebnisanalyse



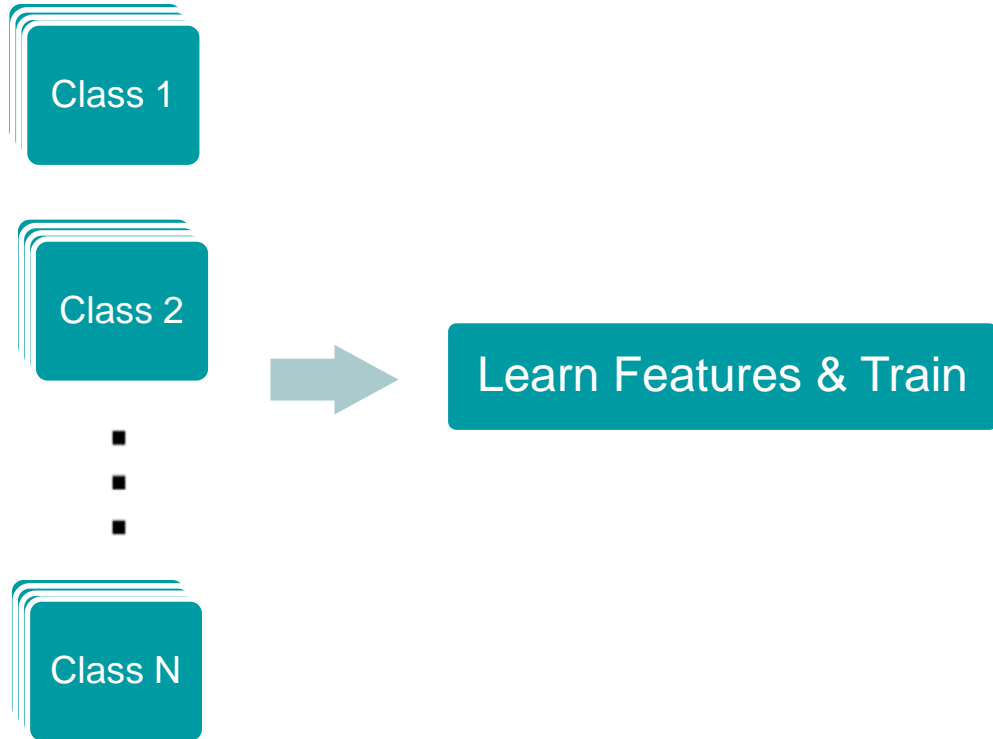


Deep Learning

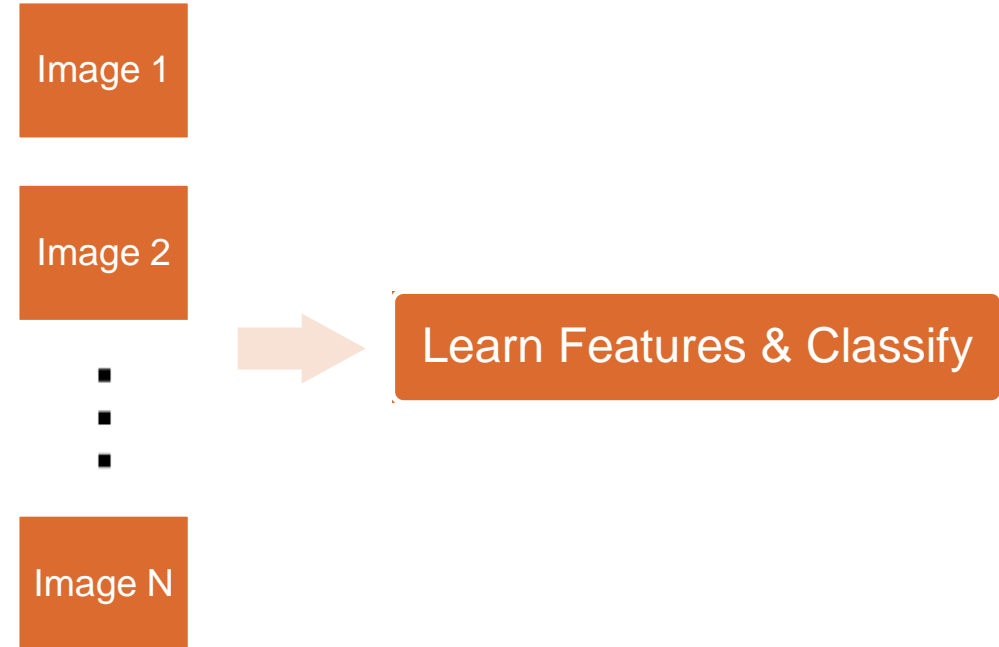


Deep Learning

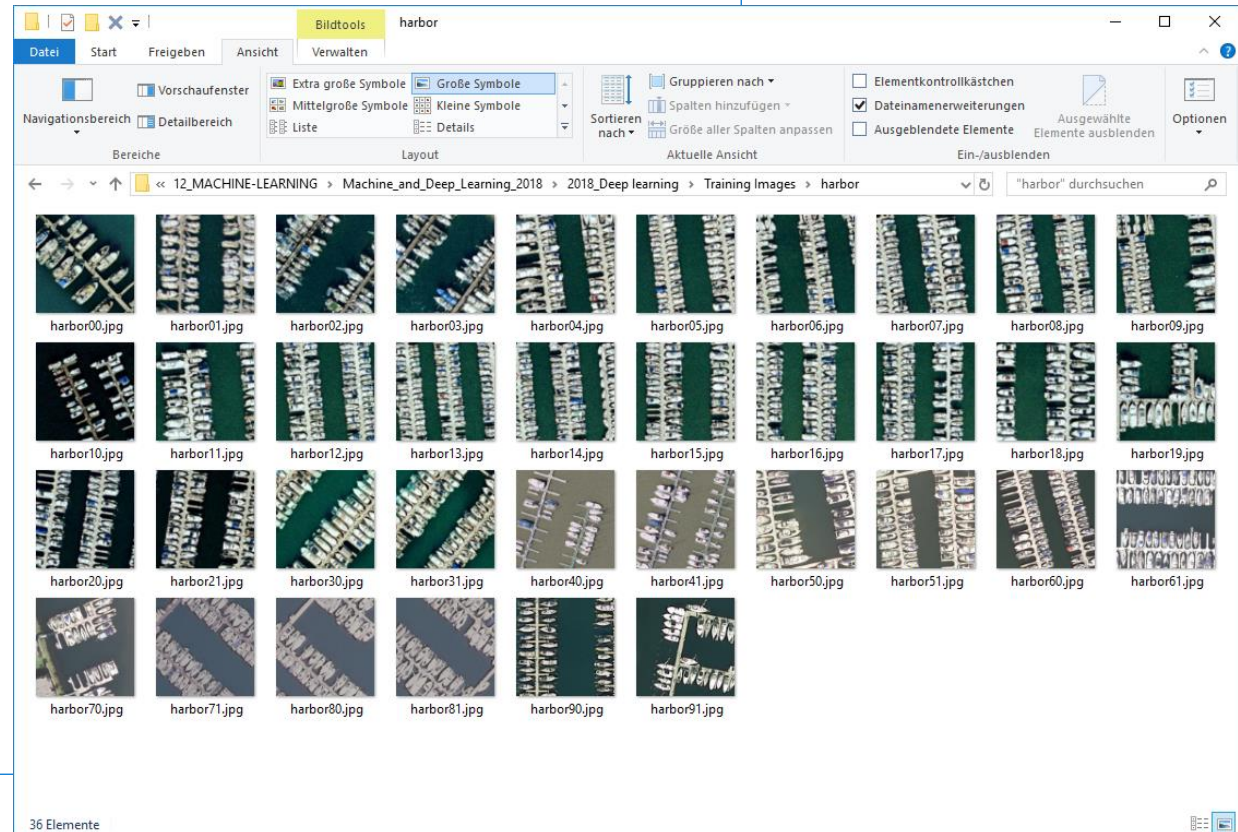
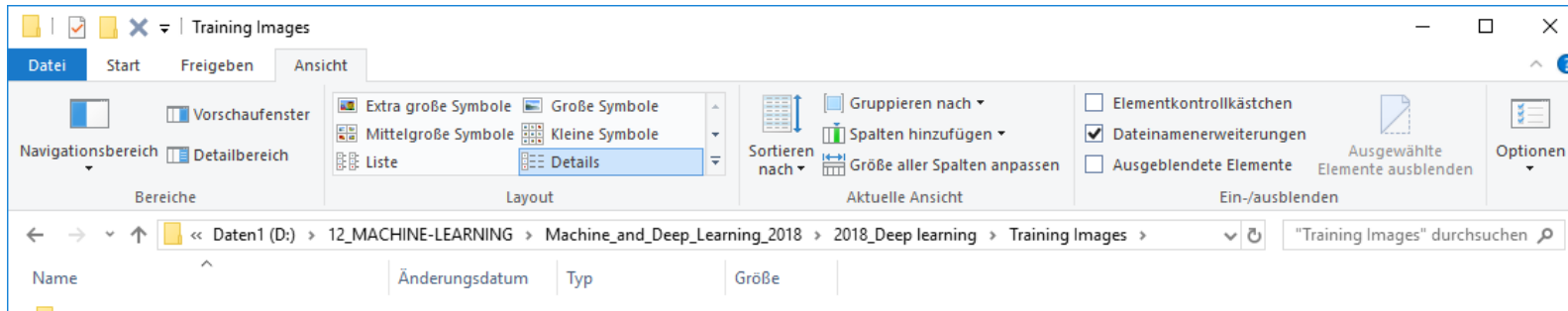
Training Images



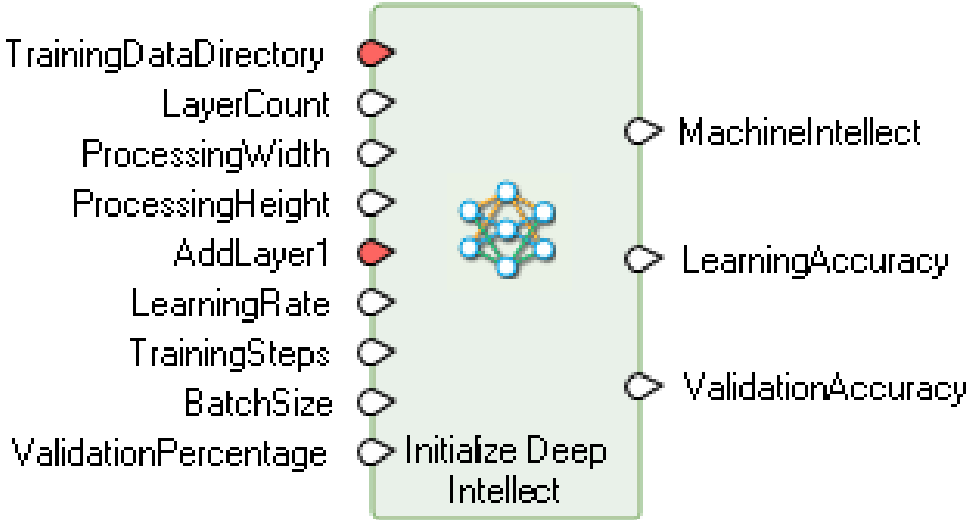
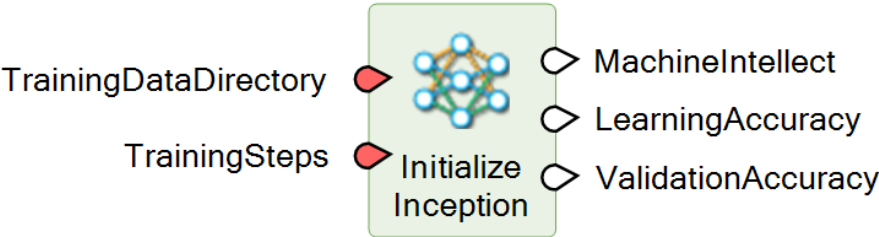
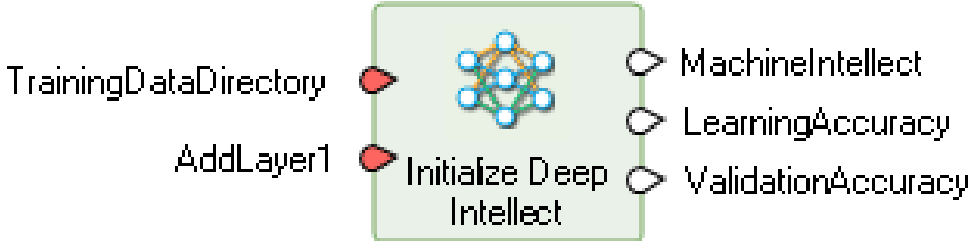
Images to Classify



Umfangreiche Trainingsbilder werden benötigt

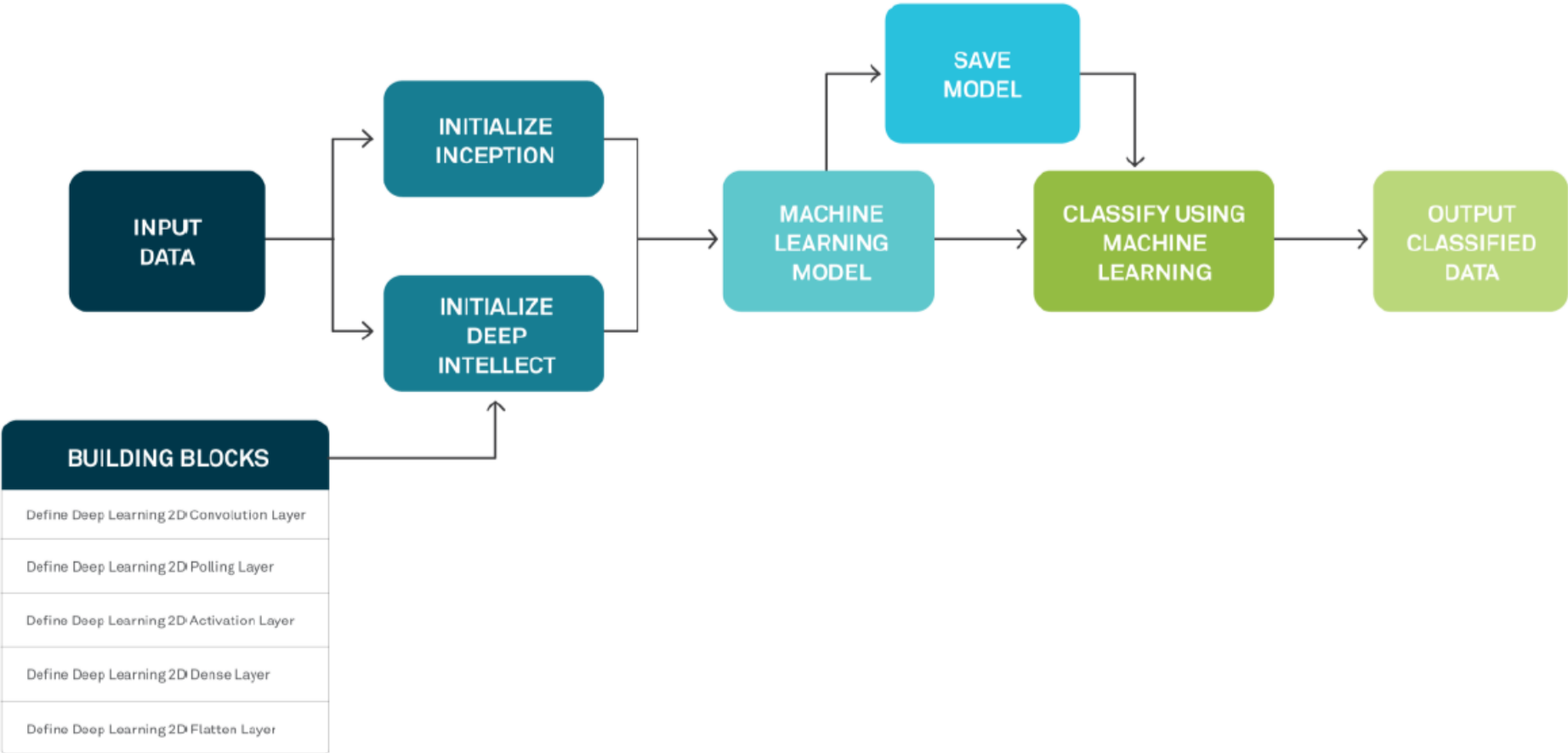


Initialize Deep Intellect



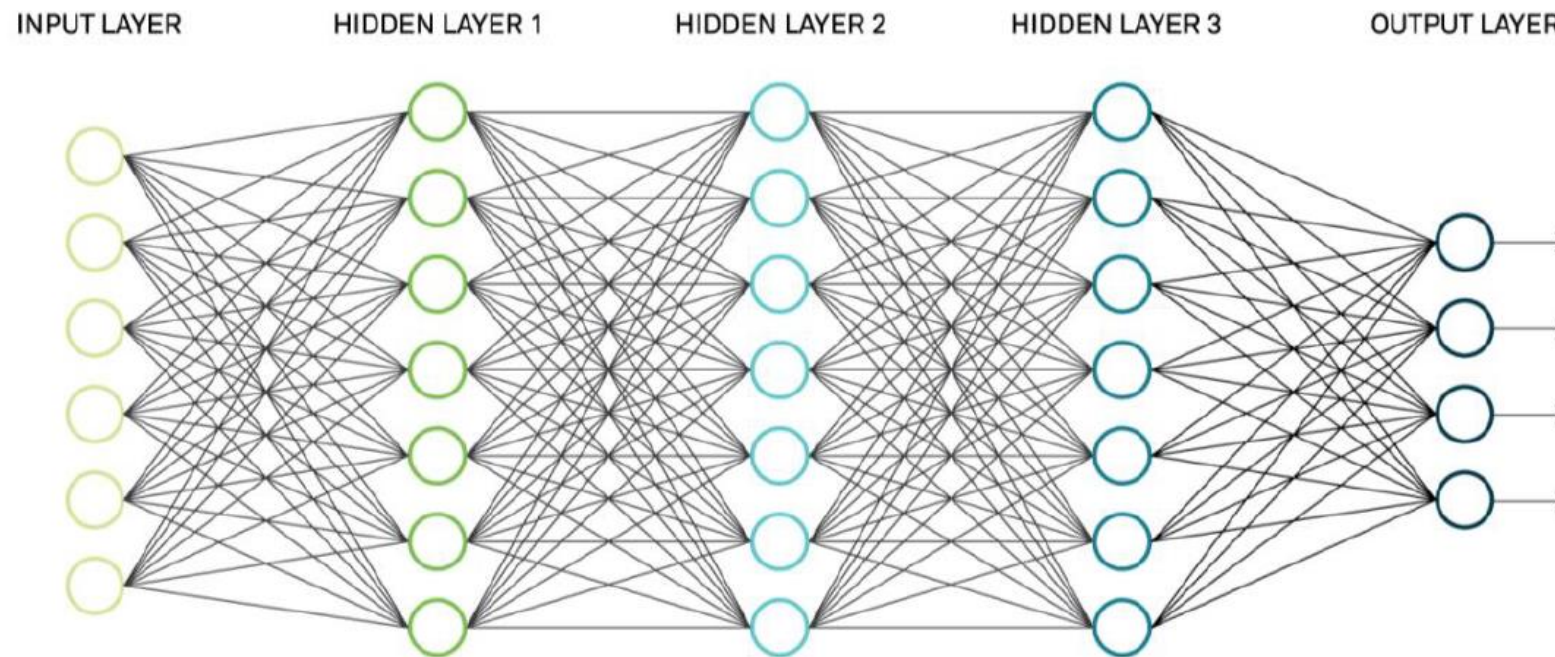
Trained by Google

Ablaufschema Deep Learning in IMAGINE



Deep Neural Networks

- Input layer – This is an input to the network. No computation is done in this layer.
- Hidden layers – All the computations are performed here. The input data is transformed through a series of operations.
- Output layer – Represents probability scores



A neural network with three hidden layers

CNN – Convolutional Neural Networks

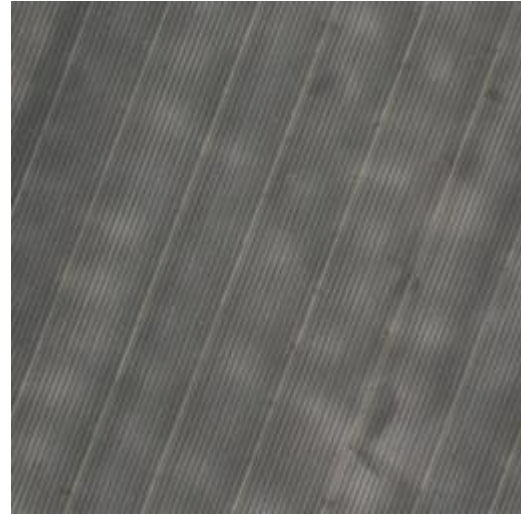
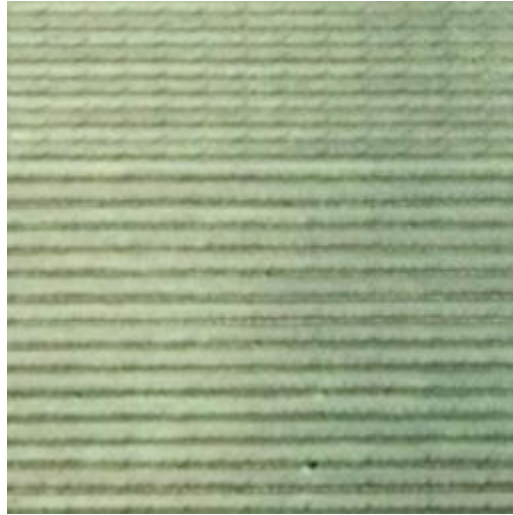
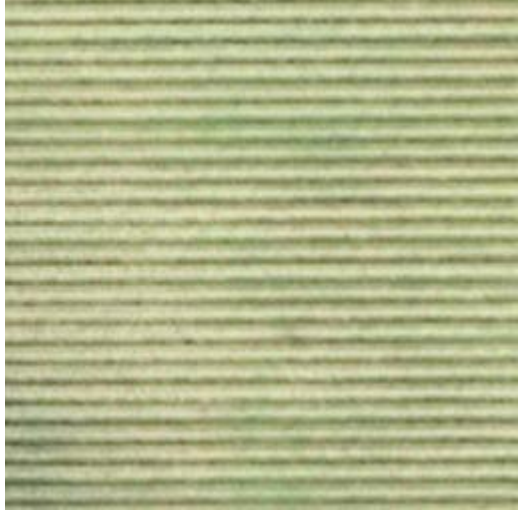
Convolutional Neural Networks (CNN) sind gut geeignet für bildrelevante Aufgaben

Der **Input Layer** wird durch die bereitgestellten Bilddaten abgebildet.

Hidden Layers wenden eine Reihe von Filtern auf das Bild an, um Features zu extrahieren und zu lernen, welche davon für die Klassifikation verwendet werden sollen.

Die Werte im **Output Layer** repräsentieren die Wahrscheinlichkeit eines Bildes zu einer Klasse zu gehören.

Trainingsdaten Acker



Testmosaik zum Klassifizieren



Deep Learning results

- 2120 images classified
 - Size: 8960 rows, 15360 columns
 - Divided into 2120 grids
 - 1941 classified correctly
 - 91.56% accuracy

Land Cover Type	Omissions	Commissions
agricultural	6	1
airplane	6	3
baseballdiamond	5	4
beach	1	0
buildings	15	19
chaparral	1	0
denseresidential	26	32
forest	1	0
freeway	8	7
golfcourse	5	6
harbor	1	2
intersection	5	17
mediumresidential	29	12
mobilehomepark	11	23
overpass	2	11
parkinglot	2	3
river	5	6
runway	11	4
sparseresidential	12	5
storagetanks	14	7
tenniscourt	14	18

Machine Learning vs. Deep Learning

	Machine Learning	Deep Learning
Training Dataset	Small	Large
Choose your own training attributes	Yes	No
Training time	Short	Long
CPU/ GPU/ Mem	Standard	Big

Fazit

- Machine Learning können alle => Open Source Bibliotheken stehen zur Verfügung
- ABER: Hexagon Geospatial macht das Machine Learning einfach
- Machine Learning-Operatoren können in Prozessketten eingebunden und gebatcht werden
- IMAGINE bietet die Werkzeuge, Trainingsdaten und zu klassifizierende Daten geeignet aufzubereiten.
- IMAGINE bietet die Werkzeuge, Daten nach der Klassifikation zu bearbeiten (Funktionale Attribute)
- Der Spatial Modeler wird kontinuierlich weiterentwickelt.
- Entwicklungen auf dem Sektor des Machine Learning werden von Hexagon Geospatial verfolgt und ggfs. implementiert
- Weitere Bibliotheken können über Python adressiert werden (Python-Anbindung des Spatial Modelers)

Mehr dazu auf dem UGM 2018 !



06. - 07. November 2018, Germering bei München

Vielen Dank für Ihre Aufmerksamkeit!



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