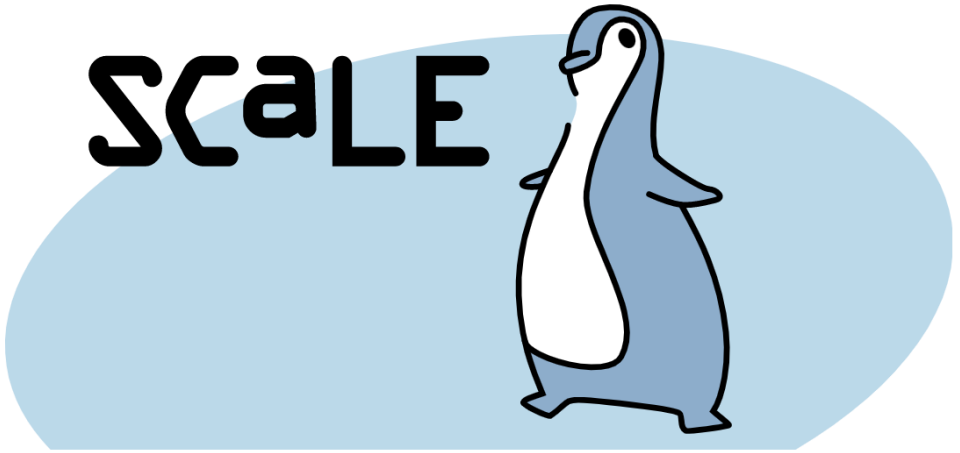
PostgreSQL And Artificial Intelligence

Slides:
https://github.com/ibrarahmad/PostgreSQLTalks/tree/main/Conferences/



19x Los Angeles, CA July 2022

Ibrar Ahmed
Principal Engineer @ Pecona LLC

Ibrar Ahmed
Principal Engineer Percona LLC.

Software Career

Software industries since 1998.

PostgreSQL Career

- Working on PostgreSQL Since 2006.
- EnterpriseDB (Senior Software Architect) 10 Years
- Percona (Principal Engineer) 2018 – Present

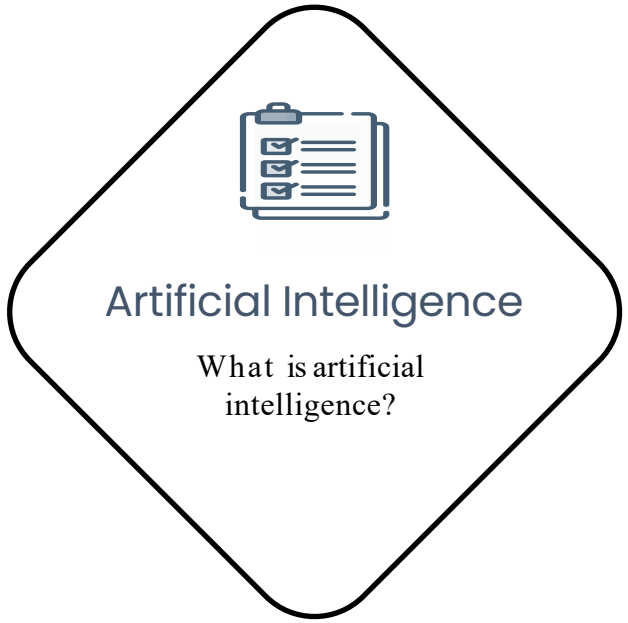
Open-source

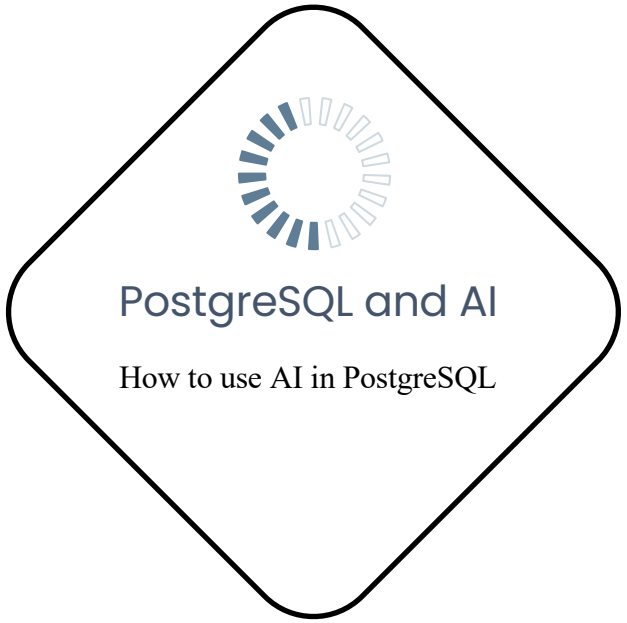
- PostgreSQL
- Google Chrome
- Google Chromium Project.

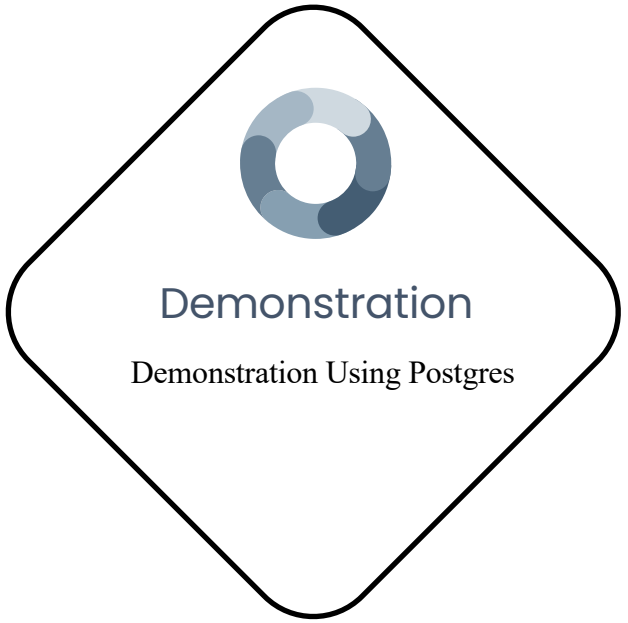
PostgreSQL Books

- PostgreSQL Developer's Guide
- PostgreSQL 9.6 High Performance

PostgreSQL And Artificial Intelegence







Artificial Intelligence

What is Artificial Intelligence?

- *Machines that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving”*.*

https://en.wikipedia.org/wiki/Artificial_intelligence

Artificial Intelligence

- *“Artificial Intelligence is no match for natural stupidity”*

  Albert Einstein

- *“A machine with strong A.I. is able to think and act just like a human. It is able to learn from experiences”*

  Albert Einstein

- *“I think the development of full artificial intelligence could spell the end of the human race”*

  Stephen Hawking

- *“The one who becomes the leader in this sphere will be the ruler of the world”*

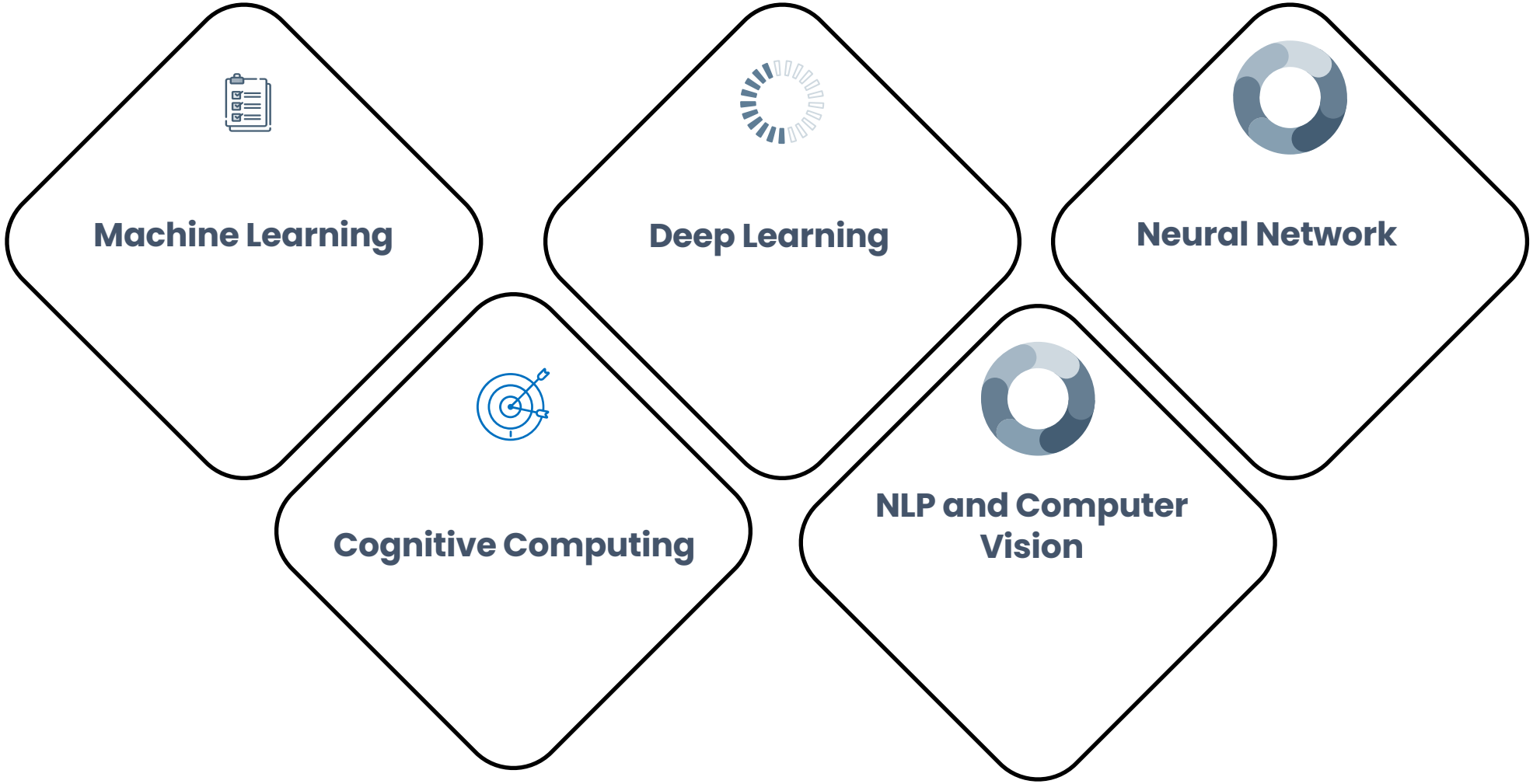
  Vladimir Putin

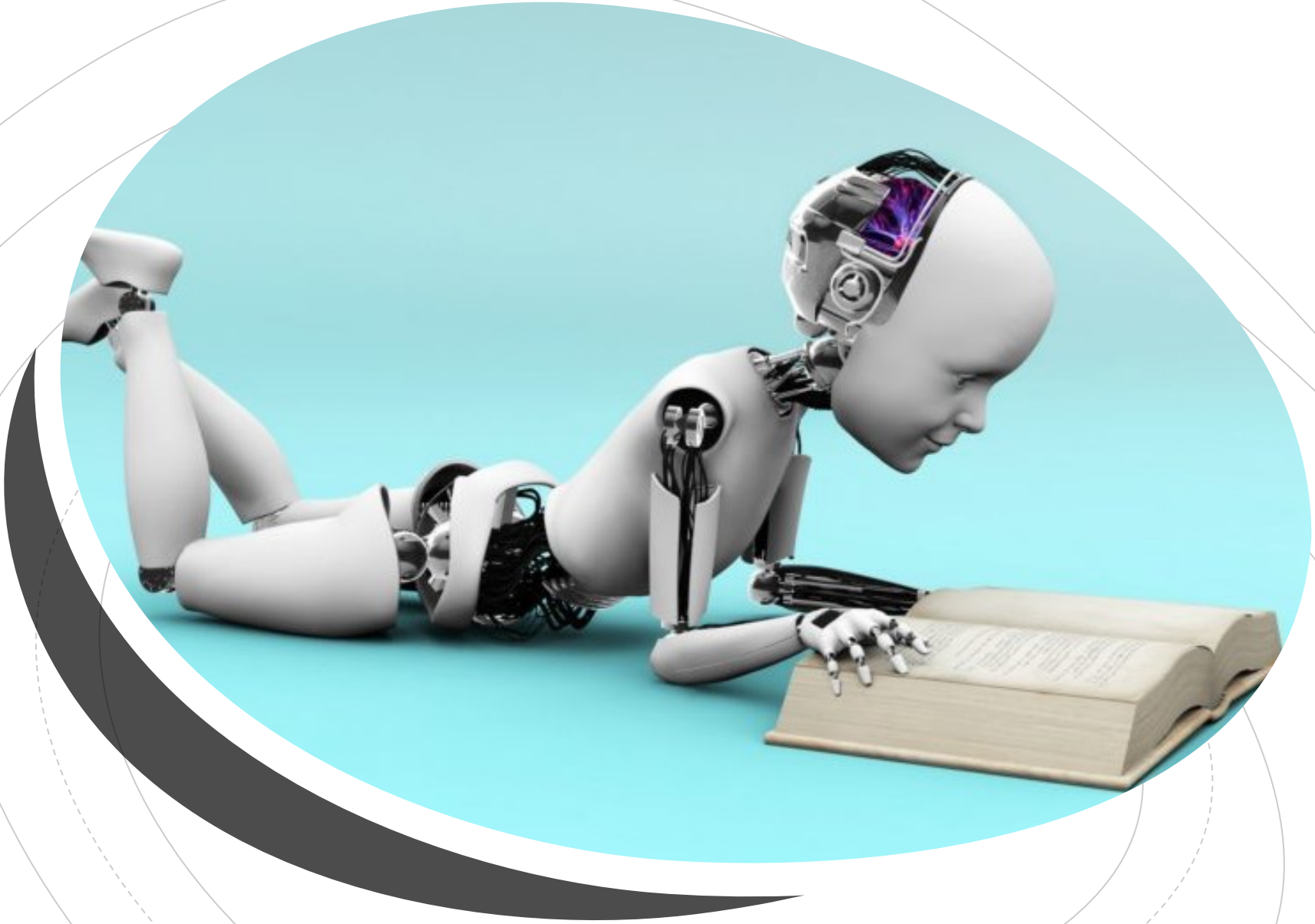
Types of Artificial Intelligence

1. ANI - Artificial Narrow Intelligence
2. AGI - Artificial General Intelligence
3. ASI - Artificial Super-Intelligence

1. ANI has a narrow range of ability to perform specific tasks.
2. AGI can perform different tasks that humans can do.
3. ASI is more capable than a human, learning from past experience and from new data to do a variety of tasks.

Sub-Fields of Artificial Intelegence

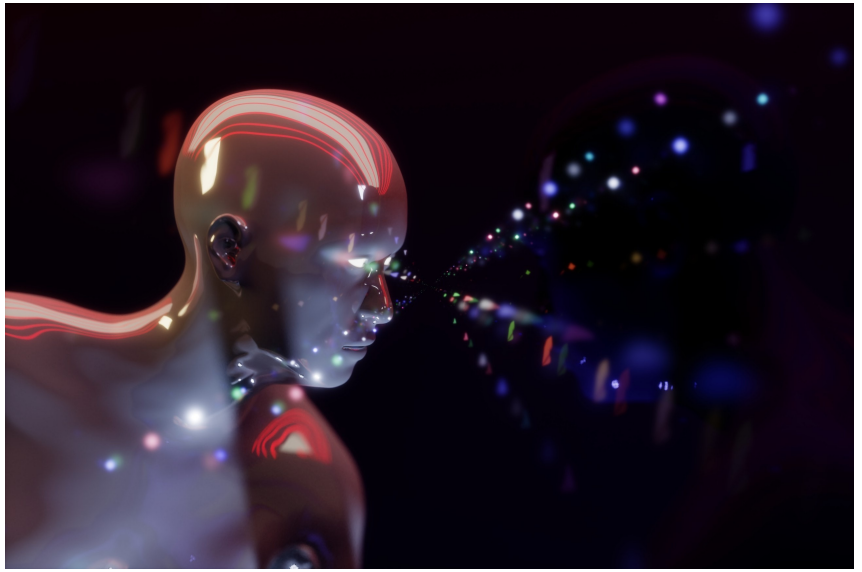




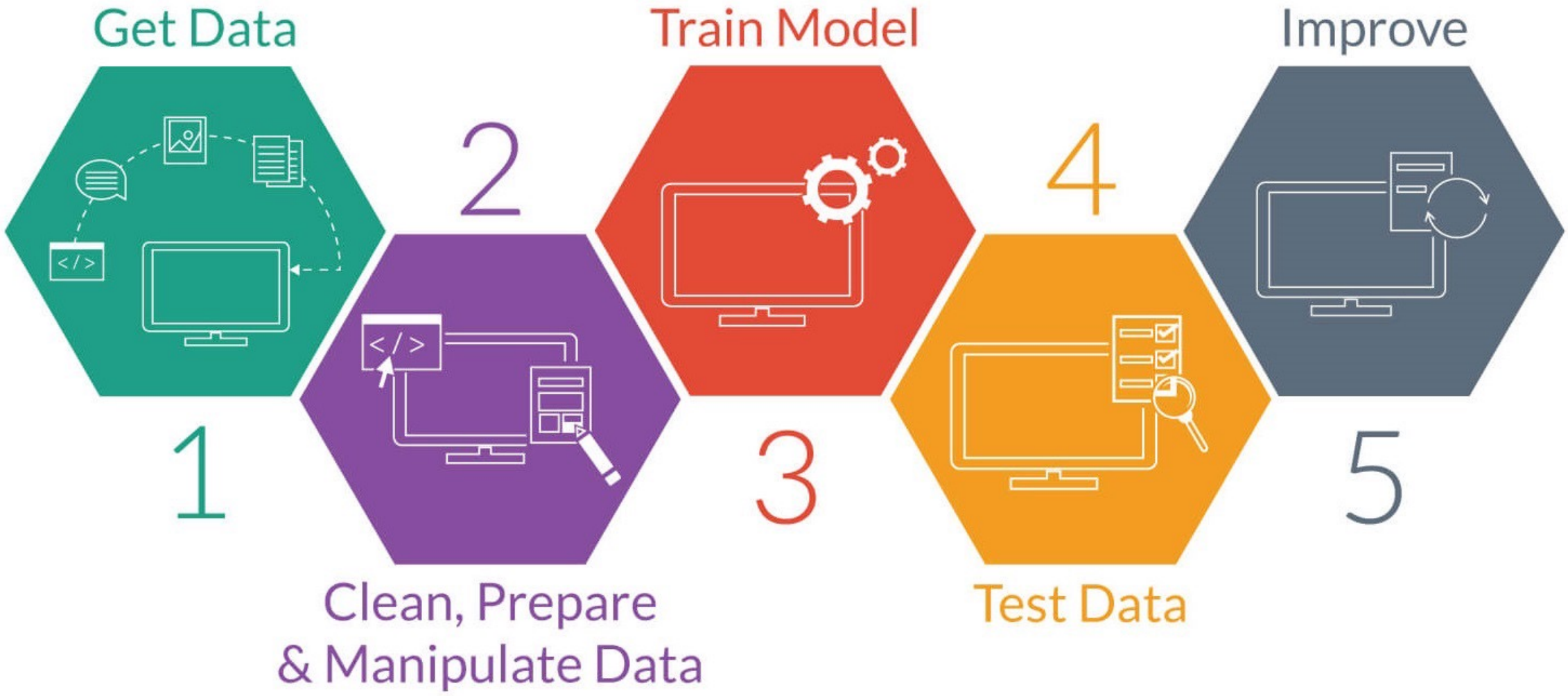
Machine Learning

Types of Machine Learning

1. Supervised Learning (Regression, Classification)
2. Un-Supervised Learning (Association, Clustering)
3. Reinforcement Learning (Robotics)



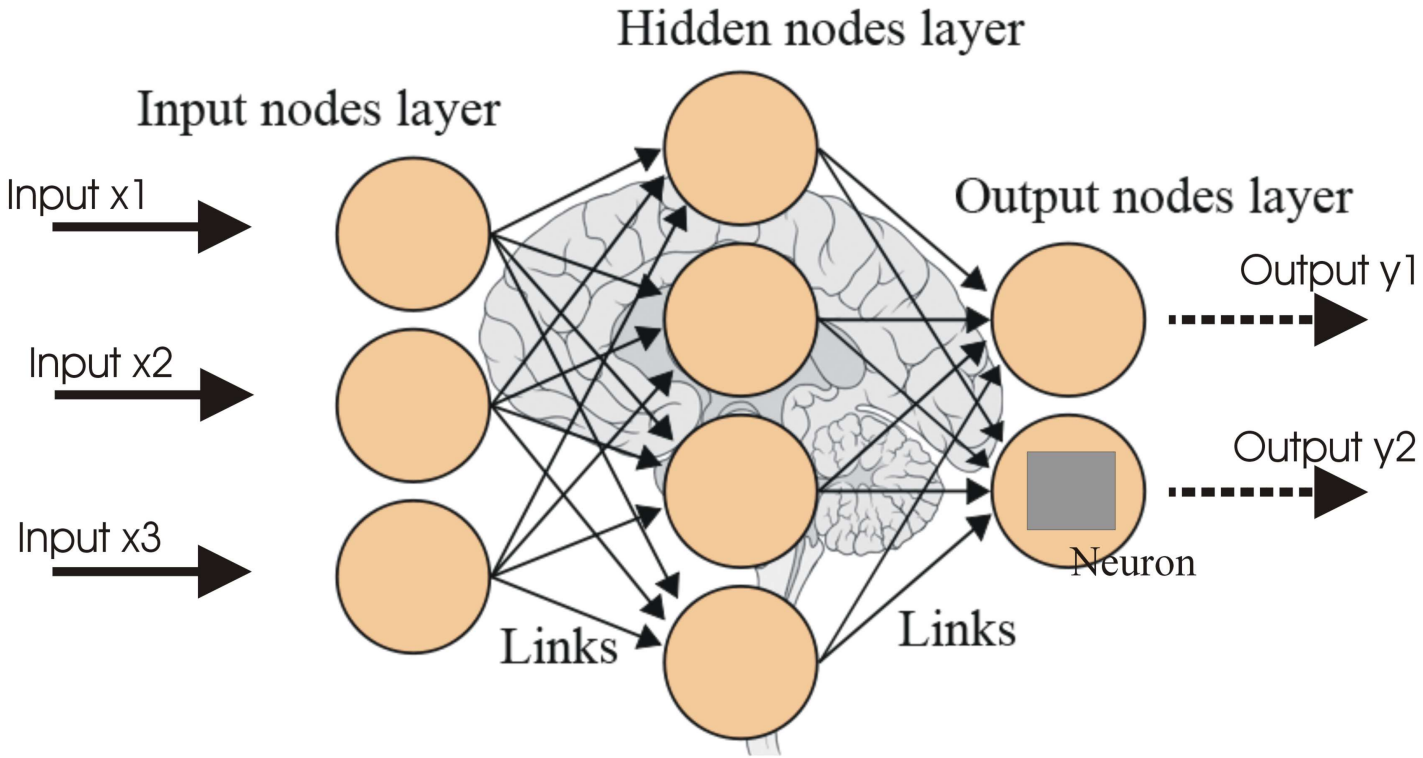
Prococess Of Machine Learning



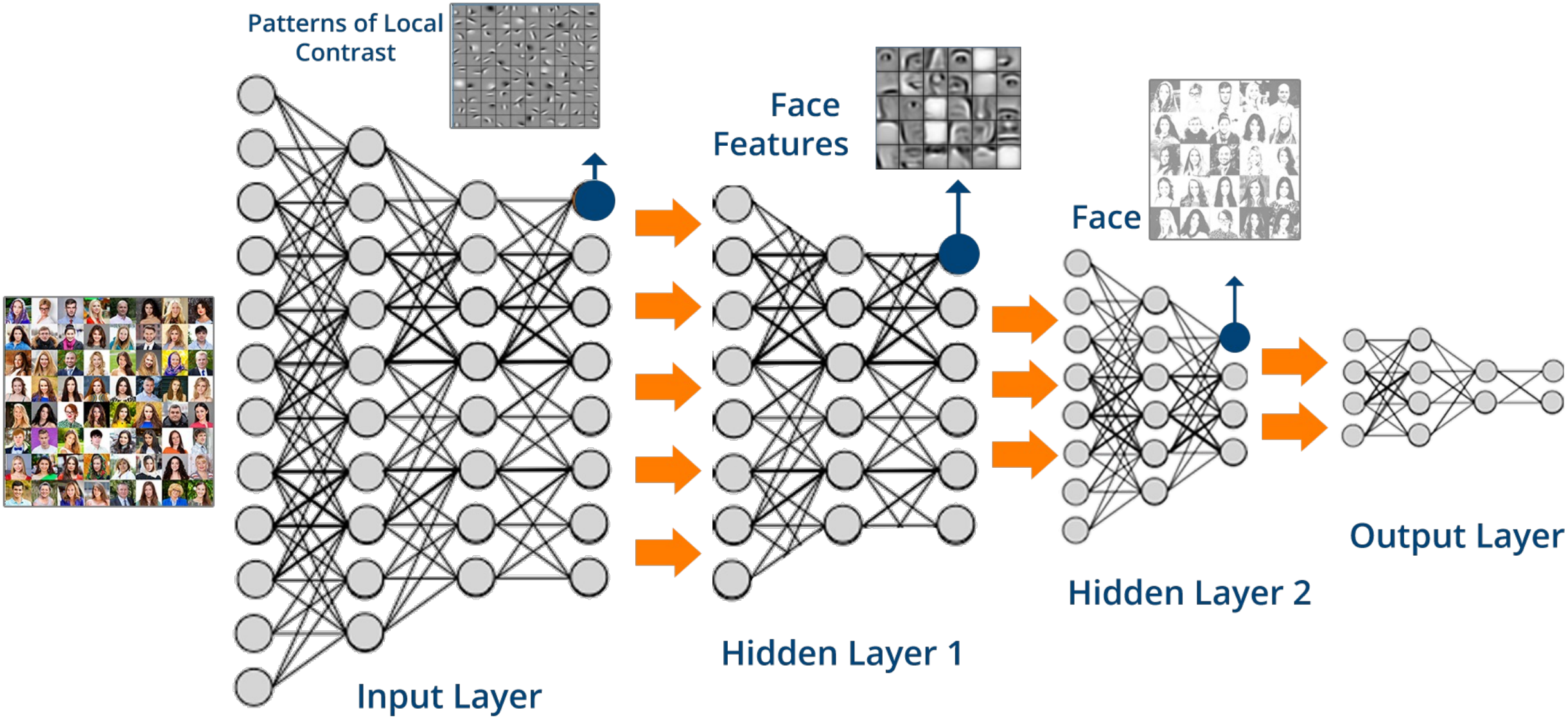
Deep Learning

Neural Networks

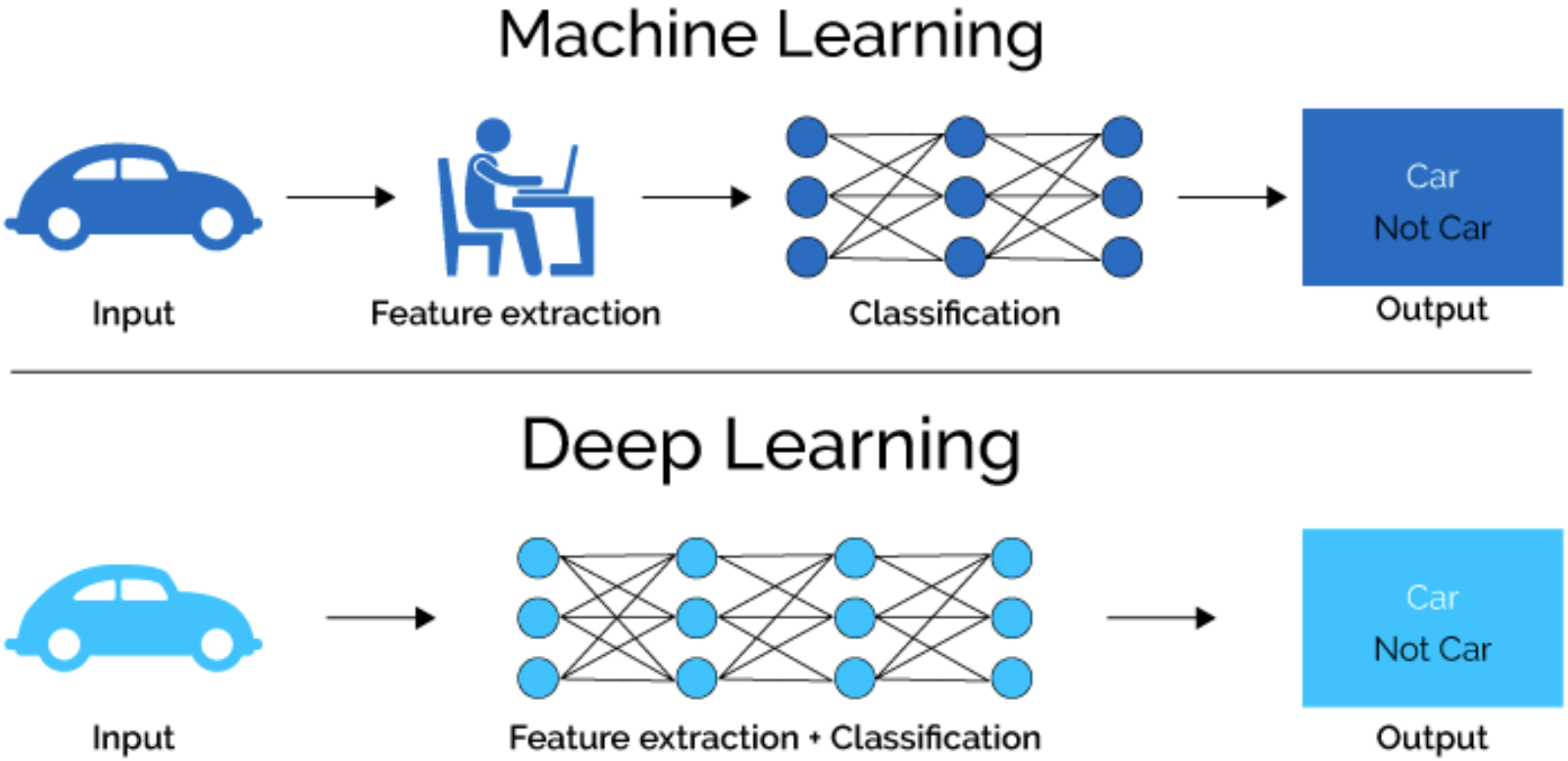
- Neural Networks, with more layers and modules
- It has a model which can take any input/output type and size



Deep Learning



Machine Learning Vs Deep Learning



Demonstration

Demonstration Using Postgres

- Does an Integer Have Non-Leading Zeros?

  - 31903 is true
  - 82392 is false

Install PL/Perl

- CREATE EXTENSION IF NOT EXISTS plperl;

- All queries in this presentation can be downloaded from https://momjian.us/main/writings/_ pgsql/AI.sql.

Generate Tensor

```
CREATE OR REPLACE FUNCTION generate_tensor(value INTEGER) RETURNS BOOLEAN[] AS $$
    my $value = shift;
    my @tensor = (
    # this many digits or more?
    (map { length($value) >= $_ } 1..10),
    # divisible by zero? $value % 10 == 0, );
    # map to t/f
    grep { $_ = ($_ ? 't' : 'f') } @tensor; return
    encode_typed_literal(\@tensor, 'boolean[]'); $$
LANGUAGE plperl STRICT;
```

Create and Populate Input Layer

- `CREATE TABLE training_set(value INTEGER, training_output BOOLEAN, tensor BOOLEAN[]);`

- `WITH randint (value) AS ( SELECT (random() * (10 ^ (random() * 8 + 1)::integer))::integer`
- `FROM generate_series(1, 10000) ) INSERT INTO training_set`
- `SELECT value, value::text LIKE '%0%', generate_tensor(value) FROM randint;`

Input Layer

- SELECT * FROM training_set LIMIT 10;

Value.	training_output	tensor
28762748	f	{t,t,t,t,t,t,t,t,f,f,f}
44550313	t	{t,t,t,t,t,t,t,t,f,f,f}
72	f	{t,t,f,f,f,f,f,f,f,f,f}
4891026	t	{t,t,t,t,t,t,t,f,f,f,f}
3413	f	{t,t,t,t,f,f,f,f,f,f,f}
62	f	{t,t,f,f,f,f,f,f,f,f,f}
86517976	f	{t,t,t,t,t,t,t,t,f,f,f}
967	f	{t,t,t,f,f,f,f,f,f,f,f}
636667644	f	{t,t,t,t,t,t,t,t,t,f,f}
36419	f	{t,t,t,t,t,f,f,f,f,f,f}

Generate Weights for Tensor (Cont...)

```
CREATE OR REPLACE FUNCTION generate_weight
(query TEXT, desired_output BOOLEAN)
RETURNS REAL[]
AS
$$
    my $rv = spi_exec_query(shift);
    my $status = $rv->{status};
    my $nrows = $rv->{processed};
    my $desired_output = shift;
    my @success_neurons = ();
    my @desired_neurons = ();
    my $desired_input = 0;
```

Generate Weights for Tensor (Cont...)

```
foreach my $rn (0 .. $nrows - 1)  {
        my $row = $rv->{rows}[$rn];
        my $tensor = $row->{(sort keys %$row)[0]}; my $training_output = $row-> {
                (sort keys %$row)[1]};
                # only process training rows that match our desired output
                foreach my $neuron (0 .. $#$tensor) {
                        $success_neurons[$neuron] //= 0;
                        $desired_neurons[$neuron] //= 0;
                        # Neuron value matches desired output value;
                        # does the value match the desired output?
                        if ($tensor->[$neuron] eq $desired_output) {
                                # Prediction success/failures that match our desired output.
                                $success_neurons[$neuron]++
                                if ($training_output eq $desired_output);
                                        $desired_neurons[$neuron]++;
                        }
                }
                $desired_input++
                if ($training_output eq $desired_output);
        }
```

Generate Weights for Tensor

```
my @weight = ();
my $sum = 0;
# compute percentage of tests that matched requested outcome
foreach my $neuron (0 .. $#success_neurons  {
        $weight[$neuron] = $desired_neurons[$neuron] != 0 ? $success_neurons[$neuron] /
        $desired_neurons[$neuron] : 0;
        $sum += $weight[$neuron];}
# balance weights so they total the observed probability;
# this prevents an overly-predictive output value from skewing
# the results.
foreach my $neuron (0 .. $#weight) {
        $weight[$neuron] = ($weight[$neuron] / $sum) *($desired_input / $nrows);
}
return encode_typed_literal(\@weight, 'real[]');
```

$$ LANGUAGE plperl STRICT;

Create Tensor_Mask

```
-- Return weights where our neuron value matches the desired output
CREATE OR REPLACE FUNCTION tensor_mask(tensor BOOLEAN[], weight REAL[],
desired_output BOOLEAN)
RETURNS REAL[] AS $$
        my $tensor = shift;
        my $weight = shift;
        my $desired_output = shift;
        my @result = ();
        elog(ERROR, 'tensor and weight lengths differ')
        if ($#$tensor != $#$weight);
        foreach my $i (0 .. $#$tensor) {
                push(@result, ($tensor->[$i] eq $desired_output) ? $weight->[$i] : 0);
        }
        return encode_typed_literal(\@result, 'real[]');
$$ LANGUAGE plperl STRICT;
```

Create Sum_Weight

```
CREATE OR REPLACE FUNCTION sum_weight(weight REAL[])
RETURNS REAL AS $$
    my $weight = shift;
    my $sum = 0; # sum weights
    foreach my $i (0 .. $#$weight) {
        $sum += $weight->[$i];
}
return encode_typed_literal($sum, 'real');
$$ LANGUAGE plperl STRICT;
```

Create Soft_Max

```
--Normalize the values so the probabilities total one
CREATE OR REPLACE FUNCTION softmax(val1 REAL, val2 REAL)
RETURNS REAL[] AS $$
    my $val1 = shift;
    my $val2 = shift;
    my $sum = $val1 + $val2;
    # What percentage is each of the total?
    my @result = ( $val1 / $sum, $val2 / $sum, );
    return encode_typed_literal(\@result, 'real[]');
$$ LANGUAGE plperl STRICT;
```

Store Weights

```
CREATE TABLE tensor_weight_true
AS SELECT generate_weight('SELECT tensor AS x1,
training_output AS x2 FROM training_set', true) AS
weight;
```

```
CREATE TABLE tensor_weight_false AS SELECT
generate_weight('SELECT tensor AS x1, training_output
AS x2 FROM training_set', false) AS weight;
```

Stored Weights

```
SELECT * FROM tensor_weight_true;
                weight

{0.020473005,0.021917565,0.024002228,0.026247077,0.028482921, \
0.030471962,0.032726202,0.034238704,0.036621932,0,0.0641184}

SELECT * FROM tensor_weight_false;
                weight
{0,0.0820682,0.07662672,0.074060954,0.07129263,0.068018064, \
0.06497674,0.061864104,0.059269458,0.058057636,0.0644651}
```

Test 100

```
WITH test_set (checkval) AS
( SELECT 100 )

SELECT softmax(
      sum_weight(
            tensor_mask(
            generate_tensor(checkval),
                  tensor_weight_true.weight,
      true)),
      sum_weight(
            tensor_mask(
            generate_tensor(checkval),
            tensor_weight_false.weight,false))
)
FROM test_set, tensor_weight_true, tensor_weight_false;
softmax

 {0.22193865,0.77806133}
```

Test 101

```
WITH test_set (checkval) AS   (
    SELECT 101
)
SELECT softmax(
    sum_weight(
        tensor_mask(
            generate_tensor(checkval),
            tensor_weight_true.weight,  true)),
    sum_weight(
        tensor_mask(
            generate_tensor(checkval),
            tensor_weight_false.weight,  false))
)
FROM test_set, tensor_weight_true, tensor_weight_false;  softmax

{0.11283657,0.88716346}
```

Test 487234987

```
WITH test_set (checkval) AS   (
    SELECT 487234987
)
SELECT softmax(
    sum_weight(
        tensor_mask(
            generate_tensor(checkval),
            tensor_weight_true.weight,  true)),
    sum_weight(
        tensor_mask(
            generate_tensor(checkval),
            tensor_weight_false.weight,  false))
)
FROM test_set, tensor_weight_true, tensor_weight_false;  softmax

{0.68860435,0.31139567}
```

Test One Thousand Values

```
WITH test_set (checkval) AS    (
    SELECT (random() * (10 ^ (random() * 8 +
    1)::integer))::integer
    FROM generate_series(1, 1000)
),
```

Second Table Expression

```
ai (checkval, output_layer) AS ( SELECT
checkval, softmax(
     sum_weight(tensor_mask(generate_t
     ensor(checkval),tensor_weight_true.wei
ght,true)),
     sum_weight(tensor_mask(generate_tensor
(checkval), tensor_weight_false.weight,
false)) ) FROM test_set,
tensor_weight_true, tensor_weight_false ),
```

Third Table Expression

```
analysis (checkval, cmp_bool, output_layer,
accuracy) AS  (
    SELECT checkval, checkval::text LIKE '%0%',
    output_layer,
        CASE checkval::text LIKE '%0%'
        -- higher/lower than random chance  WHEN
        true THEN output_layer[1] - 0.5  ELSE
        output_layer[2] = 0.5
        END
    FROM ai
)
```

Final Table Expression

```
SELECT * FROM analysis UNION ALL SELECT
NULL, NULL,  NULL, AVG(accuracy) FROM
analysis UNION ALL SELECT NULL, NULL,
NULL, SUM(CASE WHEN accuracy > 0 THEN 1
END)::REAL/COUNT(*) FROM analysis;
```

Checkval	cmp_bool	output_layer	Accuracy
6	f	{0.029198222,0.9708018}	0.47080177068710327
61859931	f	{0.5459184,0.4540816}	-0.045918405055999756
53138008	t	{0.5459184,0.4540816}	0.045918405055999756
727	f	{0.11283657,0.88716346}	0.3871634602546692
33397006	t	{0.5459184,0.4540816}	0.045918405055999756
38380069	t	{0.5459184,0.4540816}	0.045918405055999756
8915576	f	{0.4306789,0.5693211}	0.06932109594345093
446	f	{0.11283657,0.88716346}	0.3871634602546692
(null)	(null)	(null)	0.15426481181383134
(null)	(null)	(null)	0.722

Why to Use Database in AI?

Why Use Database?

- Machine learning requires a lot of data
- Most of your data is in your database
- Why not do machine learning where your data is, in a database?

Advantages of doing Machine Learning in a Database?

- Use the previous activity as training data
- Have seamless access to all your current data
- Take immediate action on AI results, e.g., commit transaction only if likely non-fraudulent
- AI can benefit from database transactions, concurrency, backup
- Other benefits include complex data types, full-text search, GIS, indexing
- Postgres can do GPU-based computations inside the database.

(https://momjian.us/_main/blogs/pgblog/2020.html#June_29_2020)

General Artificial Intelligence Uses by Databases?

- User applications
  - Performance adjustments
  - Optimizer plans
  - Index creation/destruction
  - Database settings
  - Resource usage
- Alerting
  - Malicious activity
  - Resource exhaustion

Questions

Are you passionate about Open Source?!

We're looking for you!

Join us!

#RemoteWork

APPLY NOW: percona.com/careers