A QUICK GUIDE TO HOW MACHINES LEARN
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The Bottom Line Up Front
All forms of machine learning rely on the availability of large volumes of data to train algorithms. Most forms of commercially viable MI rely on supervised machine learning, which is generally more accurate and reliable than unsupervised learning (at least for now). Therefore, the limiting factor in organizations’ ability to take advantage of MI is access to a large set of well-organized, labeled data. Improving techniques for unsupervised learning, which relies only on unstructured, unlabeled data, and semi-supervised learning, which requires less labeled data, will be critical to advancing the field of MI and increasing the number of organizations that have access to it. Until then, when considering an MI initiative, it’s important to consider whether you have the data available to support it, and if not, how you might leverage partnerships to access such data.

Supervised Machine Learning
In supervised learning, machine learning algorithms are given training data categorized as input variables and output variables from which to learn patterns and make inferences on previously unseen data. The goal of supervised learning is for machines to replicate a mapping function we have identified for them (for example, “fuzzy ears and whiskers map to the label ‘cat’”). Provided enough examples, machine learning algorithms can learn to recognize and respond to patterns in data without explicit instructions. Supervised machine learning is typically used for classification tasks, in which we segment data inputs into categories (e.g., for image classification), and regression tasks, in which the output variable is a real value, such as a price or a volume. The accuracy of supervised learning algorithms typically is easy to evaluate, because there is a known, “ground truth” (output variable) to which the algorithm is optimizing. For example, if we are using supervised machine learning to identify cats in photos, we can easily tell if the algorithm is successful in that task. Most commercial applications of MI rely on supervised machine learning.

Unsupervised Machine Learning
Unsupervised machine learning is an approach to training machine learning in which the algorithm is given only input data, from which it identifies patterns on its own. The goal of unsupervised learning is for algorithms to identify underlying patterns or structures in data to better understand it. Unsupervised learning is closer to how humans learn most things in life: through observation, experience, and analogy. One might, for example, conclude which neighborhood restaurants are popular by observing foot traffic, tidiness, and food quality—no “good” or “bad” label is needed. Unsupervised learning is best used for clustering problems—for example, grouping customers by purchasing behavior. It is also useful for “association,” in which algorithms independently discover rules in data; for example, “people who like popsicles also tend to enjoy sorbet.” The accuracy of unsupervised learning is harder to evaluate, as there is no predefined ground truth the algorithm is working toward.

And a few twists...
Sometimes researchers combine these approaches in a method called “semi-supervised learning.” In this approach, machine learning algorithms are given a small amount of labeled training data and a much larger pool of unlabeled data from which to learn. This approach can combine the best of both worlds—improved accuracy associated with supervised machine learning and the ability to make use of unlabeled data, as in the case of unsupervised machine learning.
### How Supervised Machine Learning Works

**STEP 1** Provide the machine learning algorithm categorized or "labeled" input and output data from to learn

**STEP 2** Feed the machine new, unlabeled information to see if it tags new data appropriately. If not, continue refining the algorithm

#### TYPES OF PROBLEMS TO WHICH IT’S SUITED

<table>
<thead>
<tr>
<th>CLASSIFICATION</th>
<th>REGRESSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorting items into categories</td>
<td>Identifying real values (dollars, weight, etc.)</td>
</tr>
</tbody>
</table>

### How Unsupervised Machine Learning Works

**STEP 1** Provide the machine learning algorithm uncategorized, unlabeled input data to see what patterns it finds

**STEP 2** Observe and learn from the patterns the machine identifies

#### TYPES OF PROBLEMS TO WHICH IT’S SUITED

<table>
<thead>
<tr>
<th>CLUSTERING</th>
<th>ANOMALY DETECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying similarities in groups</td>
<td>Identifying abnormalities in data</td>
</tr>
<tr>
<td>For Example: Are there patterns in the data to indicate certain patients will respond better to this treatment than others?</td>
<td>For Example: Is a hacker intruding in our network?</td>
</tr>
</tbody>
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“Children don’t have adults telling them what each pixel represents in every image they see, or what are the objects present in every image, what is the grammatical structure and the fine sense of every word in every sentence they hear. We extract most of the information from simple observation, and that is what unsupervised learning in principle does.”

— Yoshua Bengio, world-renowned MI expert, January 2016