# Module 16.1 –

# Why are we interested in Joint

# Distributions

So, I'm going to start with this question in the first module. so, why are we interested in joint distributions? I general why do we care about joint distributions? do you know, if any real-world example, that you would want to do a joint distribution

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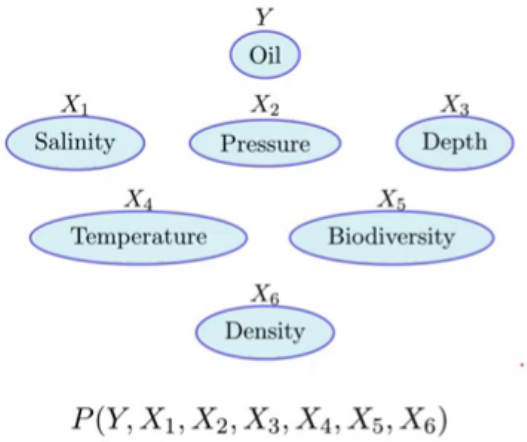


- In many real world applications, we have to deal with a large number of random variables
- For example, an oil company may be interested in computing the probability of finding oil at a particular location
- This may depend on various (random) variables
- The company is interested in knowing the joint distribution

So, in many real-worlds, applications. Right? we have to deal with a large number of random variables and we'll go back to a favorite example of my link oil that's all I care about I want to become a billionaire, someday and this job is not going to make me a billionaire so, I have to find out an algorithm, to drill oil, from someplace ok. So, for example an oil company is, interested in finding the probability of locating oil, or finding oil, at a particular location and this can depend on various random variables, why do I call these as random variables because, their values vary from location to, location, so, what's our Universal set here know, what's our Universal set in this problem, all the locations that you are interested in and these random variables are mapping these locations to certain values. Right? So, at one location the depth would be certain something, they are the other location the depth would be something, different and so, on and this set can be mapped to multiple things, that there could be multiple random variables, you could have depth pressure, biodiversity, density and so, on and this, joint distribution which is written here, it is what we are interested in right or wrong, I'm saying the company is interested in knowing this joint distribution is that fair statement.

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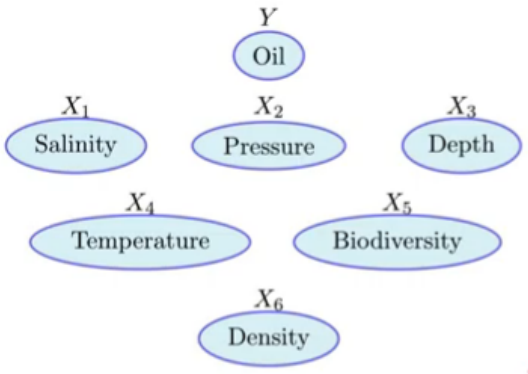


$P(Y, X_1, X_2, X_3, X_4, X_5, X_6)$

- But why joint distribution?
- Aren't we just interested in $P(Y|X_1, X_2, ..., X_n)$?
- Well, if we know the joint distribution, we can find answers to a bunch of interesting questions
- Let us see some such questions of interest

Why are, why do we care about joint distribution? We just want this conditional distribution. why do, I care about, joint distributions so, I learn a joint distribution and then marginalize it why do we care about joint distributions, I see your spirit, I mean not literally but I, I get your spirit, I don't see your spirit, but yeah, I get your spirit, I see where you're coming from but, actually all of these are yeah, sorry, no I'm not, asking you to assume anything is independent yet. You could still find P of Y, given all these variables without making any independence why do you want to do the joint distribution, in fact all if you are given. Right? Answers and the answer is a collection of all your answers, wait that this is what we are interested in today but, we might want to do something different tomorrow. Right? So, now this data is there you learn the joint distribution you can answer all these questions that you told me about now, tomorrow if you're a marine biologist or something you might be interested in the other thing what is P of X 5, given all these other variables. Right? So, now if you start drilling oil, from a location does the marine biodiversity in that location change that's again an interesting question to ask what would be the impact of salinity and pressure that could be another interesting that so, all these random variables are there, if you have the Joint Distribution you can ask all sorts of questions from that, Joint Distribution, you can ask all sorts of conditional questions on that, you could ask all sorts of marginal questions on that, you could ask independence questions . Right? So, if you want to know, if you want to find out definitely, whether biodiversity gets affected by oil mining or not you want to actually prove that is X 5, independent of Y and this you can do, it from the joint distribution so, Joint Distribution is this kind of an encyclopedia which can allow you to answer all sorts of questions about different random variables in your ecosystem, does that make sense. Right? In particular from the joint distribution you could compute this conditional distribution that you are interested in. Right? So, let us see some such questions of interest.

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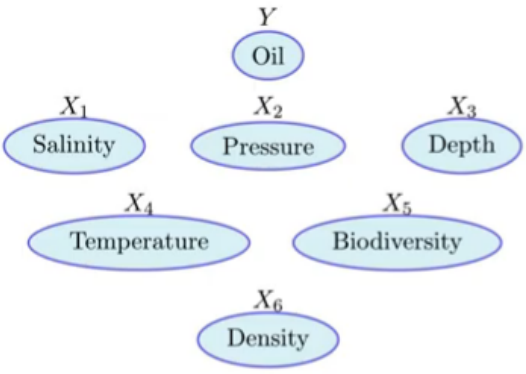


$P(Y, X_1, X_2, X_3, X_4, X_5, X_6)$

- We can find the conditional distribution

$$P(Y|X_1, ..., X_n) = \frac{P(Y, X_1, ..., X_n)}{\sum_{X_1,...,X_n} P(Y, X_1, ..., X_n)}$$

So, one is we can find the conditional distribution.

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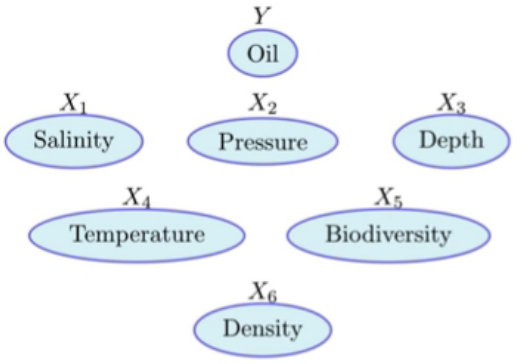


$P(Y, X_1, X_2, X_3, X_4, X_5, X_6)$

- But why joint distribution?
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How, do you get the conditional distribution from the joint distribution how will you get this from the joint distribution, divide what by what I just heard some debates so basically are dividing the joint by, what margin. Right?

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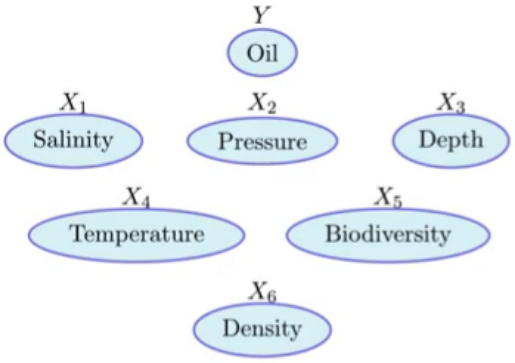


$P(Y, X_1, X_2, X_3, X_4, X_5, X_6)$

- We can find the conditional distribution

$$P(Y|X_1, ..., X_n) = \frac{P(Y, X_1, ..., X_n)}{\sum_{X_1,...,X_n} P(Y, X_1, ..., X_n)}$$

- We can find the marginal distribution,

$$P(Y) = \sum_{X_1,...,X_n} P(Y, X_1, X_2, ..., X_n)$$

- We can find the conditional independencies,

$$P(Y, X_1) \stackrel{?}{=} P(Y)P(X$$

So, these already saw that conditional is equal to joined by marginal so, the joint distribution is given to you, marginal is at least on paper, straightforward because you just need to sum up, for all variables of course I encourage you to do, it on paper and see how much time it takes but at least on paper that's easy so you will just get it from the joint distribution and the marginal distribution you can get the conditional distribution and now I could be as creative as I want I could put any variable on the left hand side and, many variable on the . Right Hand side I could put sets of area on the left hand side, Right Hand side, depending on what kind of questions I find interesting in the given problem at the hand we can also find the marginal distributions I would want to know, what is the biodiversity, generally, across the ocean or what's the temperature and so, on and I would want a distribution for, that we can find conditional independencies ,why do we care about conditional independencies again, all of these are valid arguments and today one main thing which I would like to emphasize on is wire conditional independence is important and among various reasons I will probably focus, mostly on the practical aspects which are computational efficiency, as well as efficiency in terms of number of parameters there because, eventually we are going to do some modeling, modeling in the context of machine learning and, and that's how we care about parameters and so on Right. Okay? so, so that's just to motivate why do we care about joint distributions and key answers here the straightforward answer which I said is a summation of all the answers you say what is that if you have the Joint Distribution, you can answer all sorts of questions that you're interested. Right? Marginal's, conditional, independencies and all of these and all of these are important. Ok?