CMPS 10 Lecture Notes: Lecture 12 (2-11-2016)

Question: What did we say information was

- Information is that which reduces the set of possible worlds.

Imagine that we have a set of all of the people running for President.

- Names like Clinton, Trump, Sanders, Rubio, Cruz, Christie, Kasich, Bush
- This is the set of possible worlds. A year from now, we will be living in one of those worlds.
- So NOW, what is a single bit?
  - A Bit is anything that corresponds to a left/right or yes/no question.
  - What is an example of that?
    - Well, you could do it per candidate. You could ask the question: will Bush win yes or no.
      - That is the equivalent of putting the Bush dot on one end of the set, and the rest of the candidates in another set.
    - You could bisect the first set, and ask if the winner will be on one half or the other
      - And a bisection that is of great interest to us in this case in Democrat or Republican.
      - So, you split the world into into two with a bit. You split the space in half with a single bit.
- What is an example of a bit that will give you a lot of money?
  - Will the stock market go up tomorrow?
    - (and note that it is JUST as valuable to know if the stock market will go up or down tomorrow.)
      - You can buy options. Often times done with a margin call. You call the stock broker up and say "can you LEND me 100 shares of company shares today, and I will return them to you tomorrow) so the loan is in shares, not in money. Your broker lends you the shares, you *immedietely* sell them for today's (high) price. Then tomorrow you buy them at a lower price and you return them to your broker. That is known as a margin call.
      - You can also do an option. An option is a form of a contract. There are a put option and a call option. A contract to buy or a contract to sell.
      - For most stocks there is something known as a derivative.
      - I have a business, and my business relies a lot on the price of wood. And the price of wood is significantly affected by fluctuations in the currency I use to pay for wood. So, let's say that i buy wood from Europe so I need to pay for it in Europe, but the exchange rate from the dollar to the Euro changes a lot based on lots of things that have NOTHING to do with wood. So, we note that I buy wood at this price, I put in all of these factors, and we realize that we can sell for a certain amount of money in the US that we are happy with. So we are happy with today's world. But in the future we want to expand our business, and then because of random things, the dollar to euro exchange rate gets worse, and now the cost of wood has gone way way up. What do we do? How do we solve this problem?
      - You go to your bank, and your say, Listen, I really love today's world. And neither you nor I nor anyone has a particularly good idea about what is going to happen later on down the road (let's just assume that's true for the moment). So, I would like to sign a contract between the wood guy and the bank. And let's just say that, for today, Euro and dollar are equally. And the contract is: the bank is obligated to pay you based on TODAYS exchange rate. And if the rate changes in your favor, you don't have to exercise this! You can use the better rate. So from your perspective only good things happen, from bank's only bad things. This is called an option because you have the option to exercise this contract.

Price of 1 Euro in US Dollars

- Contract that says "I will always be able to buy 1 Euro for 1.2 dollars.
- Another contract might be buy 1 Euro for 1.1 dollars.
  - Why would you ever choose the 1.2 dollars? BECAUSE it's less risk for the bank, so the contract will be less expensive to buy into.

- Now there is the 6 month contract vs the 1 year contract. The 1 year contract offers all of the insurance of the 6 month, and then some.
- But what if contract was different: x months from today, you can walk into the bank, and buy Euros for 1.2 dollars.
  - If on that day, x months from now, the Euro costs less than 1.2 dollars, then you'll just buy like a regular person. But if it costs more than 1.2 then you WILL exercise the contract.
  - So, given this form of contract, what is more expensive. 6 months or a year from now?
    * Again: both contracts give you the right to walk into a bank a certain amount of time from today.
    * Obviously, the bank will charge some premium TODAY when starting this contract, because otherwise the bank is only at risk. So today we need to pay them an up front amount of money.
    * So the question is: will they ask for more money for a 6 months from today contract, or a 12 months from today contract.
      · Why is there more risk for 12 months? Because there is more time, it is further out from the future?
      · Let's be clear: both contracts say things. X months from now, you can walk into the bank and perform a transaction. (not DURING the next X months).
      · Which one should the bank ask for more money.
      · The answer is 12 months. The 12 month contract should cost MORE. And the reason is because there is more uncertainty.
      · Today oil is like 20 dollars a barrel. It is very reasonable to believe that tomorrow, oil is going to be between 15 to 25 dollars. It is very unlikely that tomorrow the price will shift by more than 5 bucks. But if you say that, a year from now, I will buy a barrel of oil for 20 bucks, that is a very expensive contract, because a year from now, no one has ANY IDEA how expensive oil is going to be.
      · So, the question: what is the total value of all such contracts currently at play in the world? What is the sum? And value of the contract depends very much on the residual uncertainty as to if you are going to exercise it or not.
      · And each of them has a numerical value. If you were to add all of them up, what is their total financial value.
      · Guess: 50 trillion?
      · put another way: Is it more, or less, than the rest of the world economy?
      · There is something called Gross Domestic Product (GDP), how goes it compare?
      · It's a factor of 50. There is a cloud, 50 times the world economy, that is hanging above our head in the form of these contracts.
      · There is this huge, huge, betting market, that has a huge impact on the lives of people, and most people aren't even aware of it.
      · And what it primarily trades on is information.

There is a huge market for weather information, weather predictions

- Has huge impact for food, oil, and everything.
- If you can predict the weather than you can make a lot of money
- Most weather models are pretty good for a few days, but it becomes very difficult to predict the weather 10 days out from now.
  - Obviously you can collect statistical data. You can ask questions like "for the last 100 years, what was the weather like in February 21st for Santa Cruz)
    * Let's say you are specifically asking what the temperature at noon was.
  - And so if you do that, you end up making something that looks a little bit like a bell curve.
  - But if we are asked specifically for tomorrow, then we can do much much better than this, because we know TODAY'S weather.

The way that we solve it is by solving huge huge systems of differential equations.

- So we make a model that cuts the atmosphere into little cubes
- And we keep track of relevant information (e.g. pressure) in each of these cubes

- And then you try to determine how they all interplay with each other.
  - Alright, so if we have all of these systems of equations, why do we only go out 5 days. Why don't we go out 10 or 50 or a 100 days?
  - What goes wrong with our models?
  - Why do we only have good prediction for a few days, but then it quickly becomes entirely hopeless.
    * Again: for the next two days it is super good, then next twoish days it is somewhat decent, then it really falls apart after about five days.
  - Why can't computers figure it out?
    * Guess: Too many variables? WELL the number of variables stays the same...
    * Guess: Diminishing accuracy: correct, but where does that come from? There is a rapidly increasing amount of uncertainty.
    * How many have heard the technical term CHAOS?
    * How many have heard of the butterfly effect (a butterfly flapping its wings causing a huge storm).

Imagine that the blackboard is laying flat, so that it is parallel to the earth.

- Three are three points, R, G, and B
- And these are the vertices of the points on a triangle.
- And so we are dealing with an equilateral triangle.
- And there is a magnet at the vertices.
- And then on the ceiling, above the triangle, there is a pendulum, placed so that if you had no magnet, the pendulum would be exactly above the middle of the triangle, almost touching but not quite. (and at the bottom of the pendulum, there is something attracted to the magnets)
- And now we are going to perform the following experiment.
  - We take the pendulum and move it above a certain location, and we hold it there until it is perfectly restful, and then we let go. that is the experiment.
  - And what will happen is the pendulum will start moving around, and because the magnets are present, the movement will be influenced by the magnets.
  - The trajectory of the pendulum would be incredibly wild. You can never predict it.
  - But the pendulum is losing kinectic energy, its leaking heat, and so eventually it will come to rest.
  - And there are only four possibilities
    * One possibility is that the pendulum will return to the middle (but this is so unlikely we can probably dismiss it)
    * More likely possibilities: it will end up above one of the magnets they are fighting for the pendulum.
    * and eventually one of the magnets wins.
    * Imagine that, for every point in the plane, we paint it with the color of the winning magnet. (so we have the Red, Blue, and Green magnet).
    * Then for every point in the plane, (and we imagine this is a perfect deterministic system), we end up with a color of the winning magnet
    * That is, based on where we start the pendulum, one color will win. And we color that starting point with the winning color.
    * It turns out that if you start close enough to the magnet, there won't be much of a fight (start near green, it will be green. Start near blue, it will be blue).
    * BUT what about the interior? Do you have any idea what the interior looks like?
    * And we are thinking about the magnets as ridculously (and equally) strong.
      · There is probably some probability distribution, some pattern, but as you move closer to a magnet the pattern is more likely that color. You are imagining a kind of gradient.
      · Turns out the answer is something incredibly spectacular.

Then we saw the picture, we saw the pattern.

- And there are these gradients.
  - And the pattern occurs again and again and again.
  - The system is infinitely complex.

- If you zoom in deep enough. We saw video "Best fractals zoom ever"
- No matter HOW accurately you specify the initial position of the point, you won't be able to accurately determine where it will end up. These are colorations that correspond to experiments. The coloration on this plane tells you what the initial set up of the experiment, and the color tells you what magnet it ends up. Each of these videos shows that you cannot zoom in enough to have absolute certainty about what will happen.
- This is a very important concept. These are called fractals. Corresponds to zooming in on a domain of a mathematical function.
  * Observe pattern that you have a circle that has bumps and bigger circles the pattern happens INSIDE of itself.
  * This indicates a lack of accuracy, a lack of ability to predict. You need infinitely accuracy to be able to specify it.
  * This is known as self similar. The pattern happens inside of itself.
  * And this happens in the weather. The patterns happen inside of itself. Knowing the meterological conditions that happens today in Earth. So our division of the atmosphere into cubes that are a mile in length, is good enough
    · But if you wanted even more accuracy, you would need to divide the cubes up into half miles.
    · And even more accuracy if you could divide it up into yards. and we just don't have the means of capturing that amount of specificity.

Looking at Ferns.

- Great example of self similarity; as it goes smaller and smaller, it's the same shape, even though leaves/branches get smaller.
- The same phenomena is happening at different scales. Same thing happens in the weather.

We asked, what is a valuable bit

- And answer that was given was stock market; will it go down or not.
- What is another bit that is just as hard to predict, but not nearly as valuable?
  - But can we even predict if the last digit of the Down Jones index will be an odd number or an even number?
    * That is just as hard to predict, but doesn't really help us at all.
    * Note that this is different than the first digit! Really easy to predict
    * But the last digit is essentially going to be random.
    * But it's a single bit, if it goes up or down or is even or odd. So why is it so hard to predict it?
  - In the case of the stock market, Efficient Market Hypothesis affects things.
    * So, let's pretend that everyone that played the stock market is rationale.
    * And if you were rationale, you would only act, to buy or sell, that you had good reason to believe would actually have impact on what would happen.
    * So you are the CEO of a company, tomorrow you will announce earnings, and the earnings will be good.
    * Implies that tomorrow people will want to value your stock more. SO the only natural thing to do is to buy shares of your own company.
    * But the on act of buying shares for this company will create demand for the shares, which in turn will will raise their price.
    * So the idea is that the price of share represents all of the forces that are impacting the value.
  - Two economists walking down the street
    * One says "oh a 20 dollar bill"
    * The other says "if it was real, someone would have already picked it up."
    * They practically believe that they are NO opportunities for easy money, because as soon as one arises, people will step in and grab it. So if this 20 dollar bill was real, someone will have already picked it up.
    * Is the Efficient Market Hypothesis true?
      · In the example that was given, the action of the CEO is illegal. That is known as insider trading, you aren't supposed to buy shares of your own company in that situation.

        · So if you learn nothing else from this class, learn this: DO NOT BUY INDIVIDUAL STOCKS.
        · Do not say "I will buy stock in this company because I believe this company will do well."
        · What you are essentially saying is that you have a better understanding of what this stock should be, then everybody else combined.
        · When you say "I will buy google stock today at 6 or 700 dollars" you are only buying it because you believe it will go up, and your belief is either true or false.
        · If your belief is true, it means you have a super privledged viewpoint that allows you to acquire that belief (i.e. you are engaged in insider trading)
        · Or you only have access to the same information that everybody else has (tv, newspapers, etc.) But if everyone else in the world had that belief that means that the stock price should be even higher than it is.
    * note that professor does not say 'don't buy stocks" he just says "don't buy individual stocks"
    * it is comforting to think "The American Economy will continue to grow"
    * If we go back all the way to 1900, and we take a 10 year window and slide it over the Dow Jones, you'll find that the end price is always higher than the start price.
        · But if we change that to 5 year window, there are lots where the end price is less than the start price.
        · Change to a 1 year window, and there are TONS of examples of this.
        · But unless you only know something that the CEO would know about the company, its dangerous.

Can you think of counters to the Efficient Market Hypothesis
Have you heard of the term High Frequency Trading

- Amounts to buying and selling a stock while holding it for a very short amount of time.
  - i.e. holding it for fractions of a second.
- There are people today that try to make money buy buying a share and then selling it less than second after.
  - This has ZERO societal value.
  - What is the main moral argument of people working in finance? Why should they make all this money?
    * what is the moral argument in favor of Wall Street's fattest? They are ridculously well educated, and they have a ton of money. So what is the moral argument for wall street fatcats? Why is it okay for them to hold on to 1/10th of a percent of the money that flows through their hands?
        · This is not money that they generate or create. But it just comes to them.
    * You really need to know this... it isn't necessarily correct, but it is a strong one:
        · The pursuit of individual profit can only succeed if they end up making right directions. Where right directions are applications of capital that end up benefiting society at large. I.e. there were two entrrepeneurs that end up at the door. I can only fund one. And so I am incentivized to predict the one that will do well. If I can do that, then I am doing society a huge favor by funding the right one, because the other one would either just not succeed or they would produce something that is not considered valuable.
        · It's the case that they should be paid nothing for what they do, but there is the idea of asking how MUCh should they be paid.
    * And so when you have a computer that is buying and trading things so quickly, it is certainly not the case that you are enabling benefits to society via the distribution of capital.
        · So we are wasting money, we are digging holes to get a micro benefit
        · And there is an end game: the speed of light
        · And we are actually approaching that point, as the true barrier to the speed with which these transactions can happen.
    * So predicting if the last digit of dow jones is odd or even is a very good use of a random bit.

Alright, teacher tells us that temperature will be within a certain range tomorrow.

- Why is it the case that if we hear it is going to be between 20 and30 degrees farienheit, that is more useful than knowing if it is going to be between 65 and 75 degrees ferienheight

- Why is the first one so much more valuable.
- Chance isn't a factor; we could say that the weather is deterministic.
  - Based on that bell curve that we saw, if we look at the set of all possible worlds, it would be more historically significant.
  - It *does* belong in the set of possible worlds. However, there is a quantity in our brain that we associate in our brain that we associate with that outcome and
    - And this is completely subjective. WE have a mental model of these things. We feel that between 20 and 30 is surprising. but a meteorologist likely wouldn't be surprised.
    - So the element of surprise is a factor here. The more surprised by what you are told, the more information you received.

So we draw a set of possible outcomes for a particular scenario

- Let's say, who will be president
- And above each dot you have a little thing sticking out. And the bigger the thing, the more likely you think is going to happen.
- And now if we take the set and partition it in any way you like, and ask are we going to end up in the left world or the right world, and you tell us which world is going to be in (let's say that it is right hand side) what you have done is appropriated all of the probability on the left world (because NOW we know they have probability zero) and now shift to the right hand side.
  - How do you distribute it to the left hand side? Do they all get the same amount?
    - How many people have learned the answer to this question? How many people did anything about the probability in school? Lot's of people.
  - So, do they all get the same amount, so that the sum of the elongations?
    - Is that what he will do? NO!
  - The elongation is going to be proportional to the length of each one!
    - If one dot had 10 percent chance, and another one had 20 percent chance, the 10 percent chance one will receive half as much elongation as the 20 percent one.
  - So if we are told that a democrat wins the election, we distribute the probability from the republicans to the democrats
    - But did we receive any information about WHICH democrat would win? NO.
    - So, if today, we are willing to bet on Clinton vs. Sanders, whatever bet we are willing to take today not knowing who will win, that is the same bet today now knowing if a democrat or a republican will win.
      - Kind of the same thing with a list of even and odd numbers, you divide it in half, but it doesn't tell you much about the amount of odds are evens. Now as it turns out, it does tell you which side has more evens or odds but only by one. And as the size of your list of numbers grows, that difference gets smaller and smaller.