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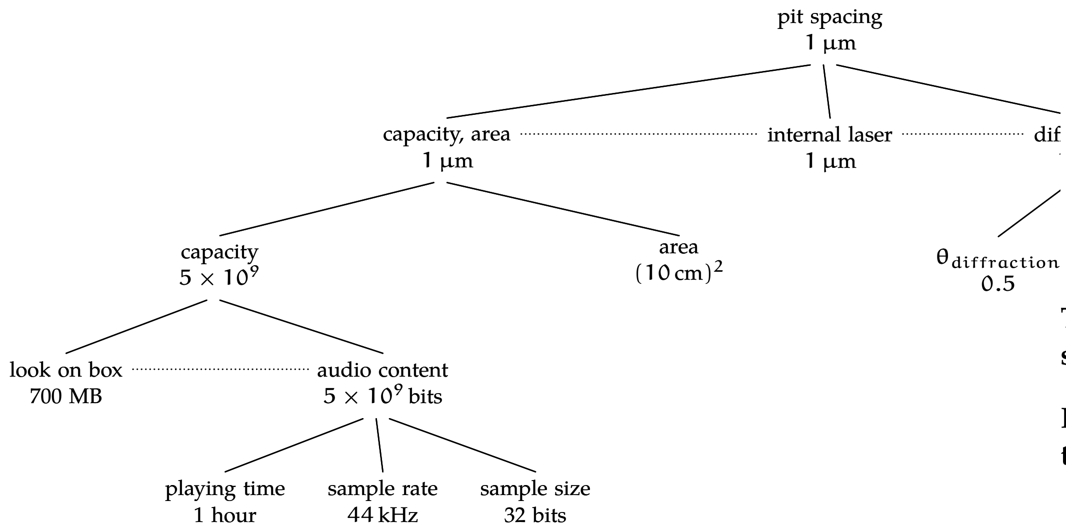

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For practice, here is a divide-and-conquer estimate using trees throughout:

▶ *How much oil does the United States import (in barrels per year)?*

One method is to subdivide the problem into three quantities:

- estimate how much oil is used every year by cars;
- increase the estimate to account for non-automotive uses; and
- decrease the estimate to account for oil produced in the United States.

Here is the corresponding tree:

It seems a lot of estimation is pure luck. It happens that lowering 15,000 miles per car to 10,000 produced an accurate prediction. Isn't that luck more than skill? And if it skill what are tips for guessing accurately?

> I feel like if you do that with all your numbers though, rounding up and down when working with your estimates. They end up canceling each other out, which is why I don't think luck has anything to do with it.
>
> Using 15 would get you 4.5x10ˆ9 barrels, which is still in that general range, especially if you use the method of calling it a "few." Maybe it takes luck or a good gut to get as accurate as he does but you can still get in the general range and at least be on the order of the correct answer, which seems to be what you're going for in these.

This seems like an overestimate, an energy report issued sometime last year or late 2008 said that we imported 60% of our oil, I imagine that rises yearly

I agree with previous comments, perhaps a better way to estimate N would be to look at the number of families in the US and assign 1 car/family

> I see two problems with this approach 1) How do you define families/ Large chunks of the population is no longer part of traditional 2 parent families 2) Families tend to have more than one car

I supposed estimating the number of barrels of oil used by cars in the US is the easiest approach, but how would you go about the other nodes (other uses, fraction imported)? Clearly these are also important for intelligent redundancy...

I find it interesting and somewhat strange that in both class and this example we only did estimation for one of the quantities (cars here) and yet we reached a result that was equivalent to the total oil use/yr. Is the trick to largely overestimate in one quantity? ie. 3*10ˆ8 cars in the United States. With these problems, should you always focus one quantity and overestimate it.

I feel that this example was a good way to demonstrate the concept, however, I feel that oil is more risky than what is presented here. Doesn't the price of oil fluctuate a lot? Or does the US just hedge for the price?

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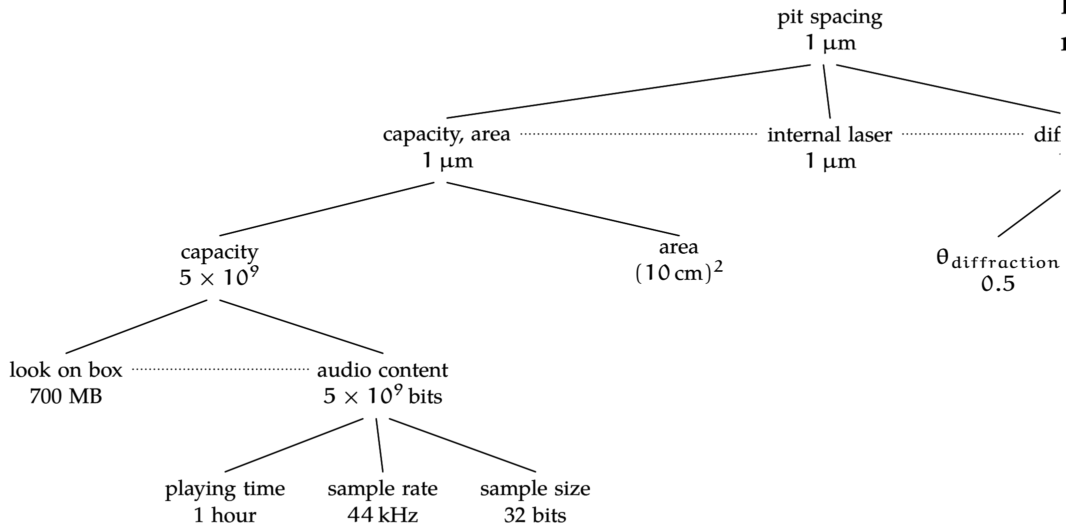

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I think as a general comment, you should consider making the first examples for demonstrating a concept something that the reader probably already has intuition. It's much easier to learn a method if you have an idea for what the answer should be. If the problem is intuitive and easy, the reader only has to learn the method and not facts and other not as important things.

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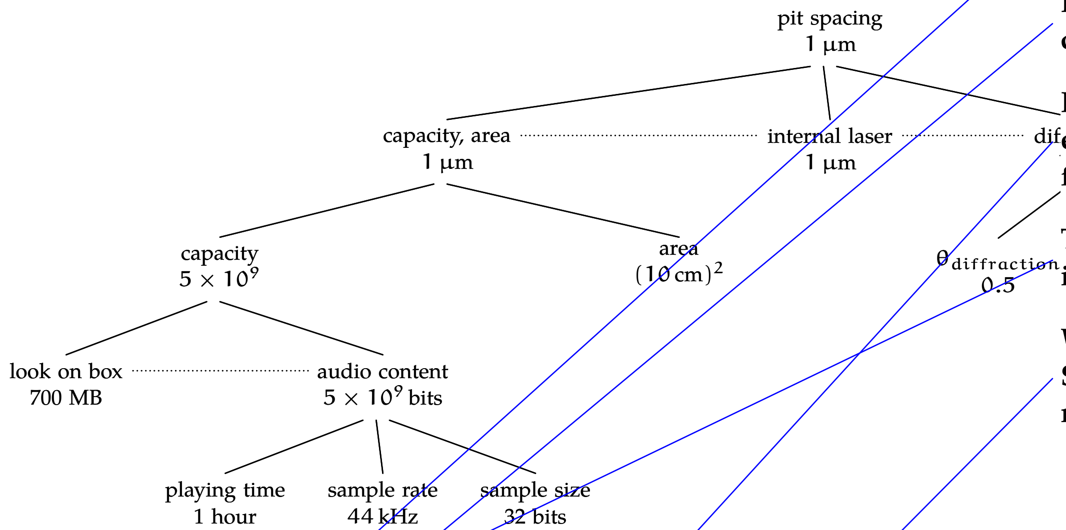

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Here is the corresponding tree:

Read Section 1.4 for Friday (memo due Thursday at 10pm).

I'm actually having trouble coming up with a comment for this section. It seems quite clear and straightforward, and I think it helps clarify the technique well.

If you end up rewriting the first few sections of the book, I think this might be a good example / way of writing the whole divide and conquer section rather than just being a follow up to separate divide and conquer and tree sections.

These are similar to back of the envelope consulting interview questions. I like that this is helpful for not only in my engineering classes but job interviews as well.

Would a suitable alternative estimate be to calculate this as a proportion of the United States GDP (either by considering input costs for sustaining the economy's production, or relative to exports)? Or perhaps as a fraction of imports?

This just sounds like it would be much more confusing, and would require data that is even more obscure from the average person than the way that the article solves it, but it still might be worth trying if you know some of the necessary numbers, such as the US's GDP, or our total imports/exports. If you try it, do you get a similar answer to what the book does?

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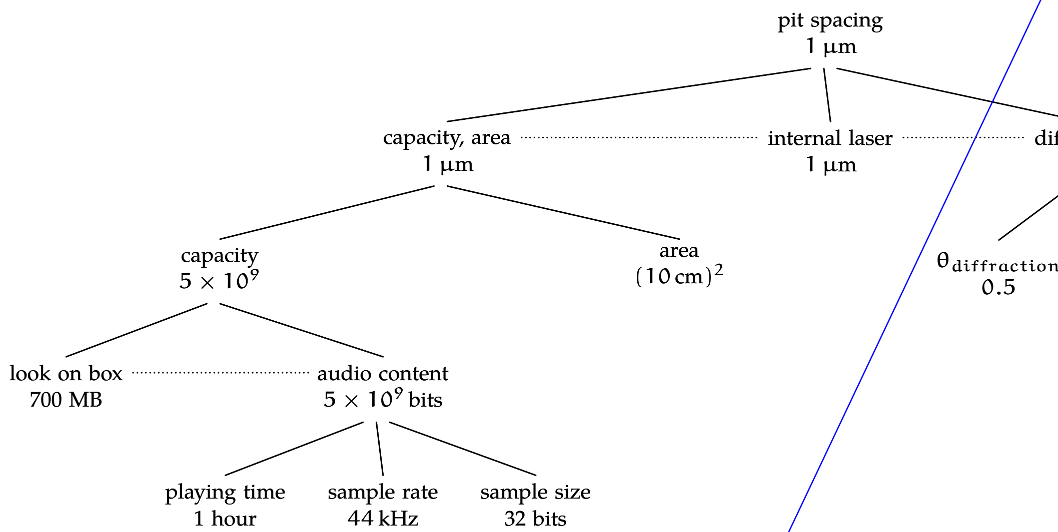

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What if I don't have a sense of the volume of the unit (barrels)? I realize the conversions can be looked up, but why specify, since it's maybe more important that the answer be easy to grasp. The question could still ask for units of volume per year, but leave the volume up to the solver. This also makes the question more universal (we've already been switching around between American and metric systems).

I guess the thought was there needs to be some unit of measurement, otherwise you can end up with people who have answers in gallons, liters, crates...anything random. So if this is specified it makes everyone's answers closer, even though it leads to another level of estimation

Well that's all good and well, but it would have been better to pick one that people have a feel for, say liters.

I don't even know if barrel is necessarily a standard size. Maybe I interpret this barrel as being the barrel from the "barrel of monkeys" game.

Er, well, there's also been a lot about the cost of a barrel in the news, so it is a fairly standard unit for oil... I think it's fair to start assuming the reader knows at least something or can look it up.

Yeah, whenever you are talking about large amounts of oil, the unit is barrels, which equals 42 gallons.

I agree with the later answers - oil prices are always quoted in barrels. However, there could be a short description to give us an approximation of what a barrel is - even something like "approximately 40 gallons" in parenthesis would be helpful.

I agree. I think that what makes a divide and conquer problem easy is if we could somehow end up with branches at the bottom of the tree that relate to numbers that are accessible in our everyday lives, although it may not be the approach to take in all cases.

I think if you had to, you could estimate the volume of a barrel. Given that it's called a barrel, it would surprise me if its volume were less than that of a cube with side length of .5 meters, but it would also surprise me if it were more than that of a cube with side length of 1 meter. That happens to put the volume somewhere between 30 to 250 gal. The true value (42) ends up being in the lower end of that range.

Oops, he sort of goes into this later, using the cost of a barrel (if you know that...) and the price of gas.

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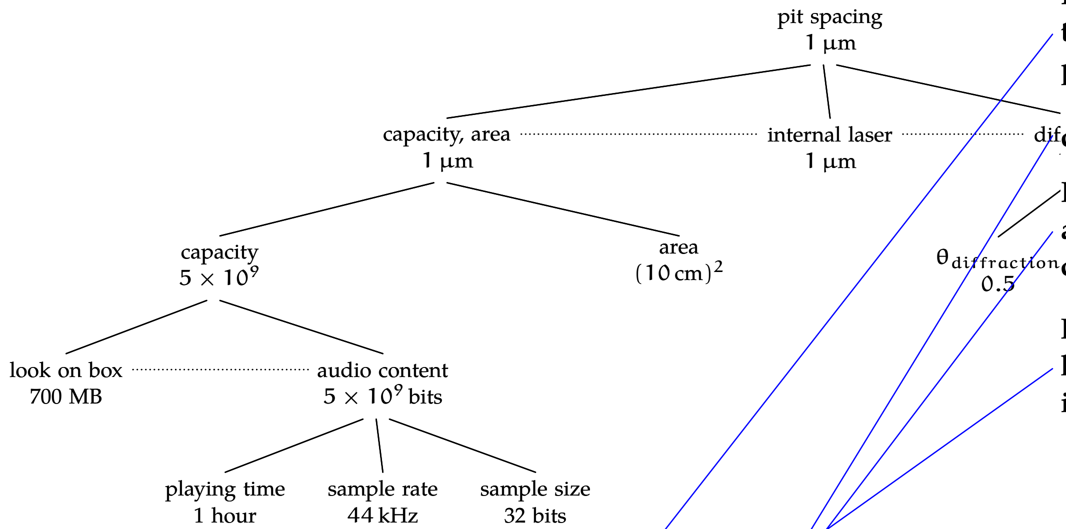

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Oops, he sort of goes into this later, using the cost of a barrel (if you know that...) and the price of gas.

I just wanted to say I really like that you have this question in here. This number crunch type question comes up in consulting interviews a lot, and I'm really happy that it is a practical example I can relate to. Thanks for putting it in!

do we know how much oil is in a barrel?

It's seems to me that the first two quantities might be solvable but without any knowledge about the US oil industry it would be impossible to get rid of this value. I understand it can't be done without this value, at this point do we have to look up certain information?

For those of us who don't know the size of a barrel, perhaps here it could be added that how ever many gallons are in a barrel? I know it'd be easier for me to conceptualize this in terms of gallons.

I also didn't know the size of a barrel and would find it useful to get a grasp of this size

Perhaps you could estimate the size of the barrel! It wouldn't be too difficult if you could assume that a barrel was 3ft tall and 2feet in diameter.

I would have thought to make an estimate of what % we make ourselves and then estimate how much we use.

I didn't follow how we accounted for the percentage of use of oil not included in our estimates.

You could also estimate how much the largest exportes of oil produce each day and estimate that the US is one of their biggest buyers...possibly even 50% of their exports go to the US and multiply out that by 365 days.

hmmmm....do you know all the oil producing countries? And what percentage of their exports go to the US? I agree that it's another way of doing, but a much harder one.

I agree too. The way done in the reading seems to allow us to make better (more accurate) estimations.

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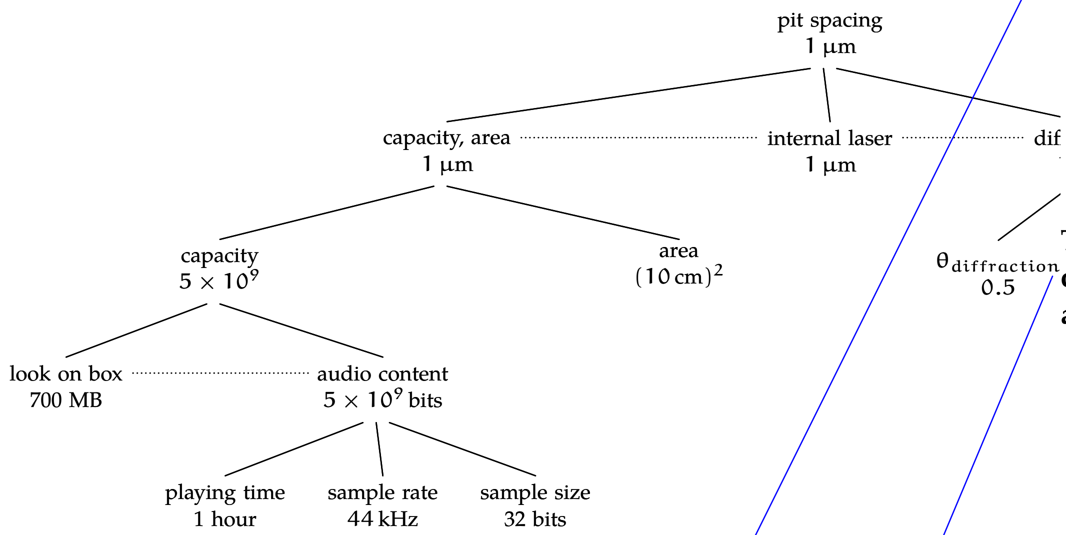

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Here is the corresponding tree:

Does the US produce enough oil per year to actually necessitate this? My impression was that the US imports a lot of oil and only makes a little bit, so it seems this may be unnecessary?

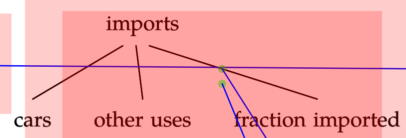
Having worked for a natural gas company, I have a bit of insight into this problem. The US actually produces 50% of the oil that it consumes, and imports the rest (with Canada being the top importer).

Wow that's really surprising - we produce half the oil that we consume? I guess this will come up later on in the reading...

This probably would not have occurred to me, given that a lot of what we hear about is our heavy dependence on foreign oil, although in the end we would only be off by around a factor of two

Without considering this he might as well have asked how much oil the US uses in a year because we'd be assuming its all imported.

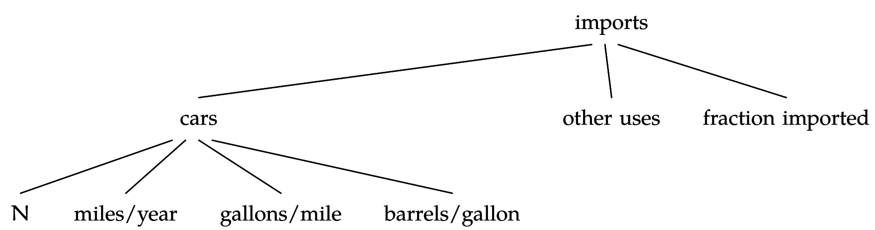
I guess in addition to not trusting the back of CD cases or coffee bags, we certainly shouldn't trust the news or politicians.



The first quantity requires the longest analysis, so begin with the second and third quantities. Other than for cars, oil is used for other modes of transport (trucks, trains, and planes); for heating and cooling; and for manufacturing hydrocarbon-rich products (fertilizer, plastics, pesticides). To guess the fraction of oil used by cars, there are two opposing tendencies: (1) the idea that the non-automotive uses are so important, pushing the fraction toward zero; (2) the idea that the automotive uses are so important, pushing the fraction toward unity. Both ideas seem equally plausible to me; therefore, I guess that the fraction is roughly one-half; and, to account for non-automotive uses, I will double the estimate of oil consumed by cars.

Imports are a large fraction of total consumption, otherwise we would not read so much in the popular press about oil production in other countries, and about our growing dependence on imported oil. Perhaps one-half of the oil usage is imported oil. So I need to halve the total use to find the imports.

The third leaf, cars, is too complex to guess a number immediately. So divide and conquer. One subdivision is into number of cars, miles driven by each car, miles per gallon, and gallons per barrel:



Now guess values for the unnumbered leaves. There are 3×10^8 people in the United States, and it seems as if even babies own cars. As a guess, then, the number of cars is $N \sim 3 \times 10^8$. The annual miles per car is maybe 15,000. But the N is maybe a bit large, so let's lower the annual miles estimate to 10,000, which has the additional merit of being easier to handle. A typical mileage would be 25 miles per gallon. Then comes the tricky part: How large is a barrel? One method to estimate it is that a barrel costs about $100, and a gallon of gasoline costs about $2.50, so a barrel is roughly 40 gallons. The tree with numbers is:

What ever happened to swallowing the biggest frog first? (That is, doing the hardest task first.) Is there a particular reason to do the easy ones first? I would personally attempt to do the hard part first, because if that doesn't work out, the easy parts are a waste of time and we need a new estimation method.

I think it's a matter of time. Why spend a lot of time working on one hard thing when you can do many easier things instead?

Perhaps it's just a confidence builder...

I agree. I would think that expanding cars to see what is needed (what children it will have) to calculate it would perhaps be better since it would give the whole picture first.

Perhaps the intention of this statement was that doing smaller calculations will help us see the bigger picture. This is just phrased so that it seems like we are avoiding the most difficult calculation until we have to get to it.

Could these categories be better organized such that we can easily estimate the major consumers (ie transportation and energy production, for instance) and then ignore the lower contributing factors?

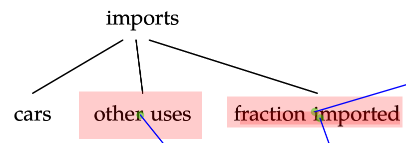
I think for your textbook the current tree is great though because it makes for a good illustration of your points - I'm just wondering for solving problems, which is preferable.

I really should read ahead before I post. The next point answers my question about the two opposing tendencies.

One thing that confused me at first was that I thought the branches were combined through addition/subtraction, but they also used multiplication. I would have tried to find values for each of the branches instead of finding one and figuring out how the other related to it (independent versus dependent branches). It seems this way that you could check using redundancy; if I calculated a value for the non-car branches and also found the multiples, I could confirm my estimates.

I somewhat agree. I think that for a simple tree like this, it is easy to remember what is added and what is multiplied but in a complex tree, there might be some value in having a convention that indicates whether values are additive or multiplicative.

Agreed. If it weren't for the other comments already here, I wouldn't have been able to correlate this graph with the math it implies. "Fraction imported" somehow doesn't feel right being on the same branch level.



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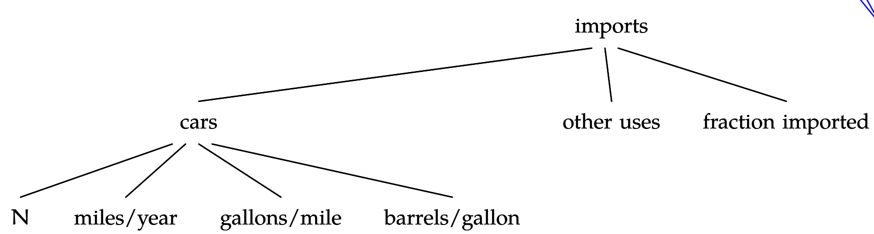

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Why do we say "fraction" imported instead of "quantity" imported? I would think a fraction would be harder to calculate.

I'm also confused by this since the other 2 values will be measured as quantities.

It looks like maybe this "fraction imported" node represents the "decrease the estimate to account for oil produced in the US," so we will multiply our final answer from the other branches by this fraction. This seems like the case because the other two branches represent the other two subdivisions of the problem that is outlined on the bottom of the previous page.

the point of this is to estimate the quantity imported...having that also be one of the branches wouldn't make very much since. Also, it's quite simple to guess at how much of our oil usage is imported as a fraction.

I'm agreeing with the first two respondents here - I think I understand what the meaning of this section is, but it would be better if all nodes located at the same level of a tree had the same units to reduce confusion.

What does fraction imported mean? How is this different from imports (the top branch)

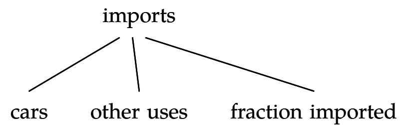
I would like to hear a little more about the specifics of other uses.

I think it's pretty clear. anything else that requires oil, but isn't cars...

Didn't the tree skip a step? We are trying to calculate the amount of oil used by the us then subtract us production in order to get imports, right? Shouldn't "fraction imported" really be the fraction of oil produced in the us? I thought this graph corresponded with the above three bullets... And if production is what this represents, how would you graphically represent subtraction in a tree?

If you said you were going to begin with the second and third quantities, why is the first quantity the second one discussed?

While I agree that we could look at it this way, i feel like another reasonable stance would just be to guess that cars represent about half of our consumption.



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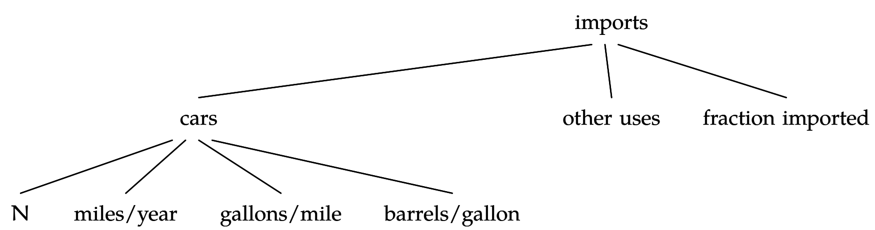

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I would not say that the automotive uses are virtually zero- it is true that cars use much less gas than planes, but there are also considerably more cars on the road every day than planes. This would lead me to only assume tendency (2) and so I would have "cars" and "other uses" marked as intelligent redundancy.

The wording of this is confusing to me.

I also have trouble with the wording of this. How could the fraction be pushed to zero? What does this mean exactly.

Basically it means this: they are trying to guess the fraction of oil used for cars. The two extremes are that most oil goes towards non-automotive uses, or that most oil goes towards automotive uses. He argues that since both are equally believable, he'll guess that half the oil goes to automotive uses - splitting the difference.

I like the concept used here. I agree that is a very plausible to use 1/2 for non-automotive usage, and it just seems like common sense that would work. I'm not sure if it was included in heating and cooling, but (and this is much smaller these days) power plant usage may also be worth a mention.

I think this should be unimportant instead if you assume a fraction of zero.

I do not see this as a good reason for why they are using 1/2.

me neither, cars use oil, so why would an argument go for a zero value? I understand that you wished to introduce a way of thinking about how much us oil consumption was used by cars, but this doesn't make sense.

it's not that it would be zero, but some might argue that (in the grand scheme of things) the amount of oil consumed by cars is negligible compared to the total consumption. it's like when you're looking at 10ˆ40 + 10 ... the 10 really doesn't count for much at that point so we can ignore it, but it's still not 0..................as for a good reason for it to be 1/2, read the comment 'i would not say that the automotive uses are virtually..."

What's unity again? Is it infinity?

unity is totality

Or in other words unity is 1, since we generally encounter it in relation to fractions.

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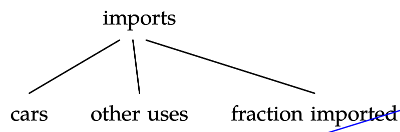

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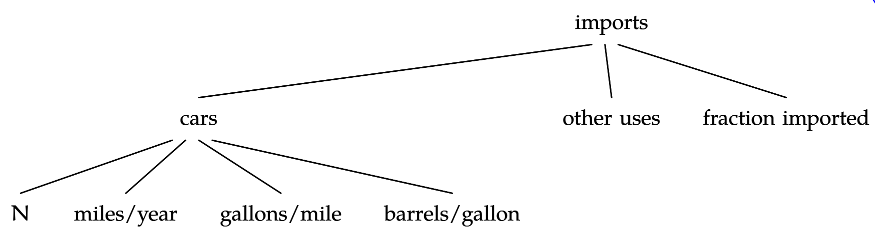

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I don't know, I thought planes consume a considerable amount of fuel. I'm sure our approximation will somehow account for this but I still cannot mentally dismiss plane fuel use so easily

I'm working on consulting interviews right now and a recent practice case I did estimated that plans use 10 gallons/mile - given how much weight they're carrying and how heavy they are, that sounds quite reasonable to me. Given that, it does seem that planes would take up an extraordinary amount of fuel.

But you have to consider that there are orders of magnitude fewer planes moving at any given moment than automotive vehicles. I'd even hazard to guess that the fuel used by the trucking industry alone in a given unit of time would be at most an order of magnitude smaller in comparison to that used by planes (assuming 10 gal/mile is reasonable).

Okay, this may just be for me, but I have to reword this to make it clearer and to explicitly define the relationship show in the tree structure—

(1) the idea that the non-automotive uses are important enough to draw the fraction of cars/total toward zero; (2) the idea that the automotive uses are important enough to push cars/total toward unity.

I also found this confusing. I would suggest making the statement sound more hypothetical.

(1) The idea that the non-automotive uses might be so important that they overwhelm the contribution from automotive uses; (2) the idea that automotive uses are so important as to overwhelm the non-automotive uses.

And maybe then talk about the effect on the fractions after you have defined what these two cases are.

So are we forced to pick one? Which is more important? non automative uses or car uses....When you say 1/2 what does that mean? Are you considering half considering both? Or picking one? I am bit confused by that comment.

What he is saying here is that the non-automotive uses are roughly equal to the automotive uses, so both uses each take 1/2 of the oil.

He is taking the intermediate stance that "other uses" account for as much oil as cars, so he just doubles the estimate for oil use from cars to get oil from other uses+oil from cars.

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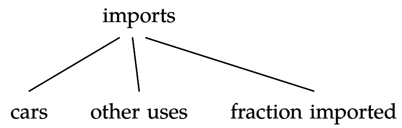

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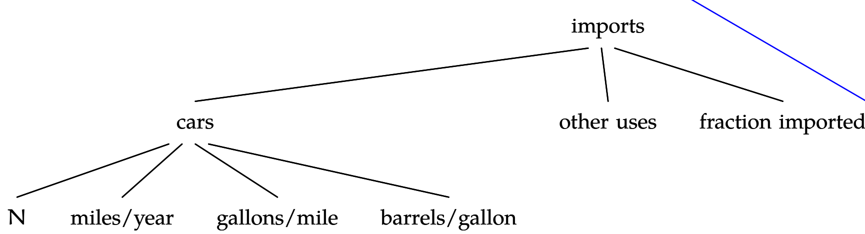

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Overall good example. After reading the comments, it seems to me that you may want to explain why you can be so loose with the percentages you guess.

It seems like a lot of people are having trouble accepting the 1/2 number. I think if you wanted to, you could relate it back to everyday life (i.e. think about how much we travel in cars, trains, trucks, planes, etc.) and break it down by how much fuel/person each mode of transportation uses. Then I suppose the oil used for manufacturing hydrocarbon-rich products would be much more difficult to estimate.

Are we allowed to trust our gut to that extent? Reasoning that seems reasonable to ourselves?

And had there somehow been 3 different areas, would it have been 1/3

I think this is reasonable, it would be tough to come up with a better fraction.

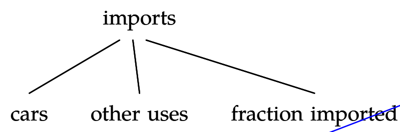
I agree that I wouldn't have been able to come up with a better fraction, but the decision to go with 1/2 seems arbitrary. Is there another way we could come up with this fraction?

Does that mean we could guess any fraction and continue with the problem with that assumption? I feel like this is an area that would get me stuck, because I'd be trying to figure out the details rather than making a guess. How do we know when to guess and when to find a more educated approximation?

Is the one-half estimate just a very rough guess or was there more too it? How much freedom can we take when approximating numbers this important.

Why? I understand that a lot of the listed things are larger than cars, but there are a LOT of cars on the road. Given that today we assumed the professors were an insignificant portion of the total staff in the school, why would it be unfair to assume that the sheer number of cars used on a daily basis (and their old needs) do not outweight the use of oil in trucks and planes by over 1/2?

because we are making 2 assumptions here: either the non-automotive uses are important (hence we can ignore the use by cars) OR the automotive uses are important (and hence we ignore the non-automotive), since 2 assumptions are equally plausible, we weight them equally and thus 1/2



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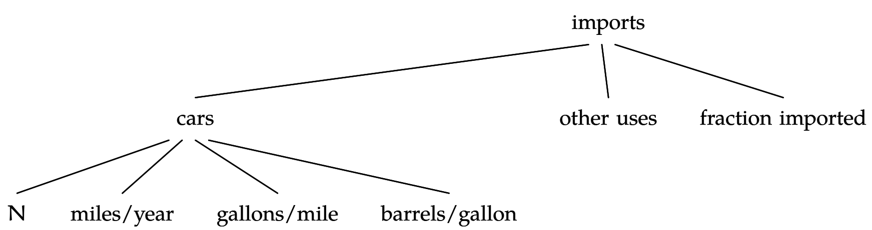

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I would agree with this estimate, I think that the non-automobile uses are very important and although these are less things, they each use more oil

seems like the accuracy of any kind of estimate here is very likely to be off by alot

This sounds reasonable but I would assume that cars use more then half the oil in this country being that there are so many. I feel as thought 1/3 would be a better estimate for non-automotive uses.

how is this estimation reasonable?

I get the 1/2 – but I don't get why we double the oil consumed by cars.

I don't get it either...what does non-automotive uses have to do with oil consumed by cars? They're sort of different by definition...

I believe the idea is that since we think it's equally likely that cars make up a vast majority and vast minority of oil consumption, we have to guess that they account for half (the middle between our two estimates)

I see that the wording in the text is not very clear. What I meant: The imported oil is used by cars and by others (trains, generators, trucks, heating, ...). The factor of 2 is my guess for the factor to increase the car estimate to arrive at the total estimate.

As with others, it makes sense that we conclude that the car fraction for oil consumption is 0.5, but when you say double it, doesn't that mean you end up with 1? As in all the oil consumed is consumed by cars? It seems like this last sentence has really confused people.

It was confusing. What I meant is that cars consume 0.5 of all oil, and imported oil is 0.5 of all oil, so car consumption is roughly the same as oil imports.

I am also confused as to how this a reasonable estimation. I'm assuming that it turns out to be pretty close but I don't understand how just because I don't have a good feeling for two potential options that I can just assume it to be half one and half the other? what is the justification for this?

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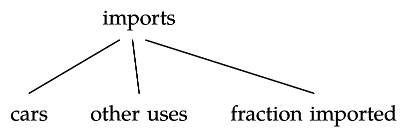

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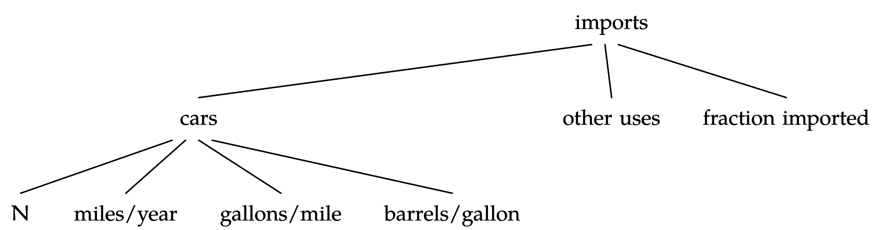

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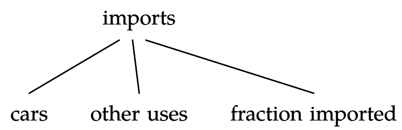
this is confusing. Exactly what estimate are we doubling? and why?

This phrase kind of makes me feel like imports are somehow consuming oil, which is of course exactly the opposite of what you mean.

Perhaps, 'imports make up a large fraction...'.

I'm still not so sure that this is a valid explanation. I think we read about a lot of things in the press that get exaggerated.



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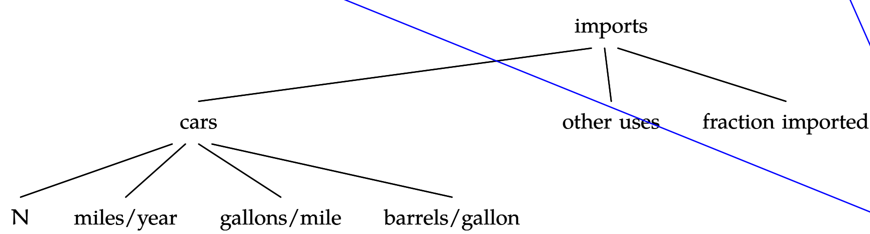

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i agree that imports are a "large fraction of total consumption." thus, if i were to estimate this, i would guess a much larger fraction of imported oil, maybe 2/3rds to 80% or so. why did you choose 50%?

I agree

I also agree. I thought imported oil would be closer to something like 90%–that seems like high enough a number to have it on the front page of the newspaper every day.

I disagree. 50% is a very significant percentage. Imagine if you were all of a sudden paid half as much at your job, or alternatively only half the people could be kept on staff. If 50% of the company was getting laid off, would you be worried?

I agree that 50% is significant. We are already assuming that 50% is used for cars, and the other 50% is used for non-automotive processes. Thus, if we lost all of our imports, it would be the same as losing the car branch or non-automotive branch.

I also agree that 50% is very significant; I think 90% is way too high, if that were the case, there would be so much more U.S. control and involvement in international countries than even now.

So I actually looked the percentage up out of curiosity and as of 2007 66.19% is imported.

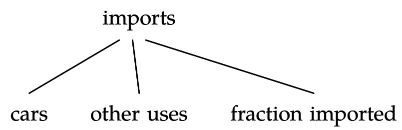
%50 seemed like a low number at first but the above comments convinced me. %50 of the oil industry is enough to receive so much attention in the press. It's strange that domestic oil doesn't receive much attention.

I'm just not sure it matters all that much, at some point. Taking 50% of a quantity is, order of magnitude, not that different from 90%. Especially when there are so many other rough estimates being made.

So if the person lacks common knowledge, how would he go about making estimates? Literally just ball park it?

Yes. Any person must have some sense of numbers in the world, and a gut-aided guess it better than none.

agreed



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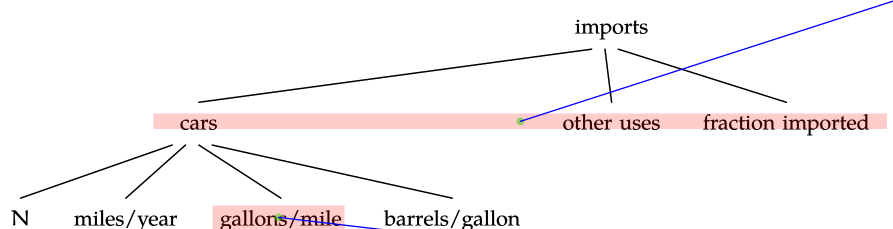

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I think this is pretty reasonable too. If I had to guess, I'd say more than half is imported.

On the first page of this reading, one of our classmates who worked at a natural gas company also said about 50% is imported, so this agrees. Hooray!

So at this point we think that half of our oil consumed is imported yes? So if we also think that cars are half our consumed oil. Can we simply say oil consumed by cars=imported oil?

Interesting point. It seems reasonable enough considering the way we're estimating, and this would make the estimating a lot easier, since would would have to double and halve.

those estimations introduce error in specific ways to our final value, so we can't simply ignore them...meaning even though they cancel each other out, they are still in the tree for reference.

That makes sense. Though I was going to comment that 1/2 seems a bit low; maybe 2/3 or 3/4 seems a bit more accurate, but I may be way off.

Though, what you said makes sense, and that tree could be 'cut down'.

How did we come up with 50%? That seems like a pretty large number.

do these all have to be values that can be multiplied together straight across the tree? can you set up a tree that needs different operators between the branches?

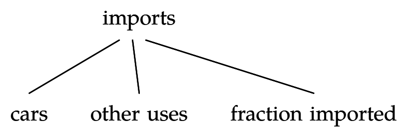
No, two of these (cars, other uses) could be added. The branches (quantities) can be linked by any operation.

This is why in the previous section people thought it would be a good idea to somehow indicate what the connection is between each leaf and branch in the tree, operation-wise

I agree. Otherwise I'm afraid we'll get overlapping estimates.

With the very wide range of MPG ratings, especially with the difficulty involved in estimating the value for hybrid cars, how difficult is it to arrive at this number?

I'd guess that it's safe to go with a slightly lower MPG rating, since a lot of cars on the road are not hybrids. We know that a sort of typical MPG rating is 20, and nothing is going to be too dramatically higher or lower than that.



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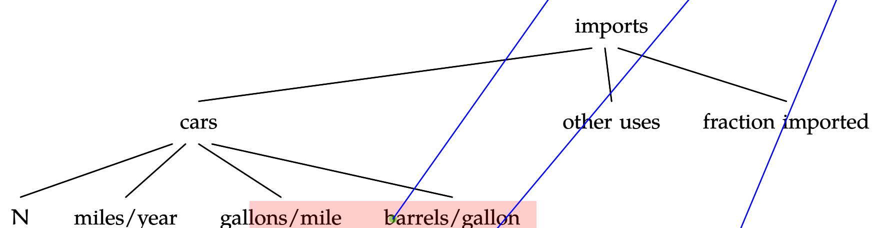

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Shouldn't these two fractions be reversed? As in, miles/gallon and gallons/barrel?

That's how you wrote them in the text above, so it seems strange to reverse them here. Also, maybe replace 'N' with 'number of cars' for clarity.

Ah, I see later that you use them in the written order to make the units work. Maybe you should specify that somewhere?

This seems like a difficult estimation problem in itself. How would we even tackle this?

I don't know about this. Every person has a car? Why not every 2 people? I think that's a safer guess.

Even if it is correct that every 2 people has a car, your answer would only be off by a factor of 2. I think the important thing is that your answer is still within the correct order of magnitude.

What about commercial vehicles and other vehicles that aren't being used for personal use? Vehicles such as Semis and company owned trucks consume much more oil than personal autos. I feel like this easily drives this ratio much higher, at least 1:1

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commercial vehicles are an interesting thought...it doesn't just increase the person/vehicle ratio, it raises the miles /year (a lot), and raises the gas/mile (a whole lot)...

maybe this could be part of other uses

I actually asked myself the same exact question. But from daily life you can roughly tell that roughly, there is 1 car per 1or2 people. Even if you are off by a factor of 2, it makes sense to think that you are still within the right order of magnitude.

Is this to compensate for the number of people that have multiple cars?

what would it matter if they aren't consuming oil?

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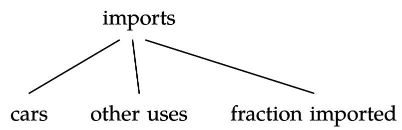

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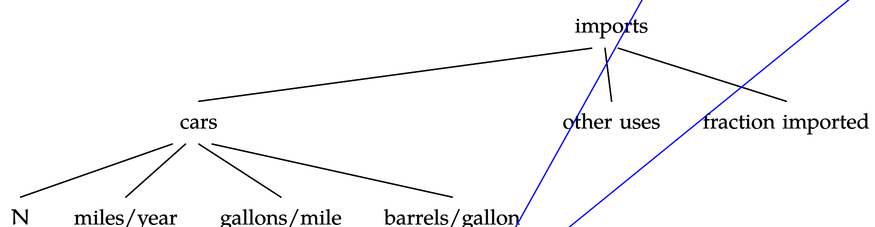

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this is a bit of an exaggeration. I would have said that the average family size is around 4 people, and each family has on average 2 cars. That seems more plausible to me.

agreed, but this only changes things to, say, 1.5*10ˆ8 people, which is only a difference of 10ˆ.5, which is probably negligible for an approximation

It is also necessary to consider the number of cars owned by companies and other 'commercial vehicles'. Thus, I don't believe it is too much of an exaggeration, if at all.

I don't think that the number is that far off, but the explanation of how it was estimated is a little strange. The average person would most like take the families + businesses etc route. For me, just saying "even babies have cars" leave out a large part of the logic behind the number, making it seem like more of a lucky guess than an educated one.

I'm pretty sure it's a joke about how wasteful the US is... that said, the approximation does happen to account for commercial vehicles and personal ones.

Id guess 1/2 that

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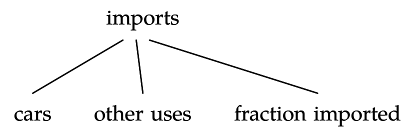

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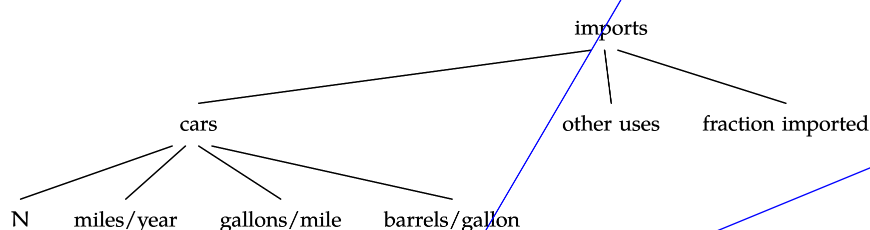

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But this, as mentioned would include everyone under 16 who can't drive, plus the very old who live in nursing homes. It seems like an overestimate to me!

But then you have people lay Jay Leno with 100 cars. And lots of people have different cars for different uses–say a truck and a car, or a summer car and a winter car. It probably balances out somewhere

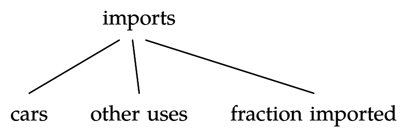
But then again, we're trying to get at how much oil is consumed, so it shouldn't matter that Leno has 100 cars since he can only drive one at a time. Therefore, it does seem that including everyone might be an overestimate.

I agree with the fact that this number seems entirely overestimated. Even celebrities with 100 cars are rare- most people have 1 car to their name and then there are some families who do not have 1 car to share so it seems as if estimating 1 car per person (including young children and elders) seems unreasonable and will provide for an overestimate. Also, the point that only 1 car can be driven at a time is a good one to consider- even people with more than 1 car can only drive 1 at a time. I think the estimate should be more like 2.4 million (by subtracting 60 million for children under 16 and elders over 75)

Even with this, there are people that work a rather large district as either a sales rep, technician, etc. that will drive way more than whatever annual mileage estimate we make. I have a few friends that drive all around the Southwest (to the tune of almost 100,000 miles per year) who, by the mileage estimate presented, would be the equivalent of themselves and 9 non-drivers.

I would think that this would be lower, like maybe half but it might be counter acted by the commercial use of cars

Wouldn't it be more fitting to approximate the number of drivers as opposed to the number of vehicles. An individual with two cars in this example is predicted to drive twice as much which I don't believe would be the case necessarily.



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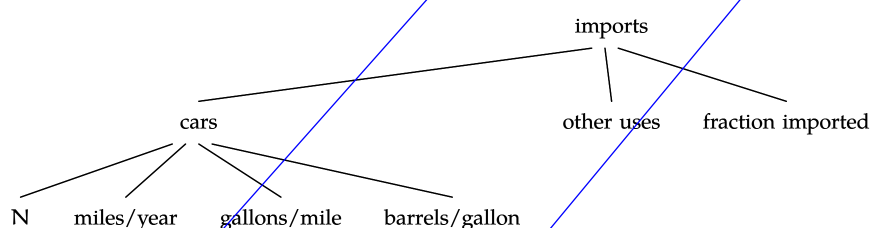

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I'm not sure if anyone else could have assumed this, but it seems like a difficult number to instantly assume. I think an easier way to get an estimate would be to guess how many miles a car goes a day, roughly 40 would be my guess... and from there get the number 15000

15000 per car seems high to me, especially if we're counting babies' cars. That implies 15000 miles per person (no carpooling) per year? Maybe half of people aren't driving significantly in a year (too young, live in cities), so that's more like 80 miles a day per driving person. Is it reasonable that every person that drives sits in their car for nearly 2 hours a day?

I can't imagine 3*10ˆ8 cars being driven 10K miles/ year. I'd say each family having one car that goes 15K is a better estimate.

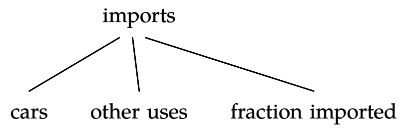
I disagree. I actually like this estimate. It seems to me that most families own 2 if not 3 cars.

It's also worthwhile to note that most new car warranties are 100,000 miles or 10 years.

my family (2 cars) travel 120 miles/weekday to commute to work (1 hr & 1 half hour commute)...that's 15K miles/year for 2 cars. Both of my parents have fairly standard commuting times for the area that I live in...I'd say that the estimate can't bee too far off, especially considering that those numbers don't take into account the fact that my dad works 6 days a week and they go places other than work...

How do we assume 15,000? just try to use personal experince?

Experiential knowledge works, but you can also do a quick estimate: 30 miles per day, 7 days per week, 50 weeks per year = 10000



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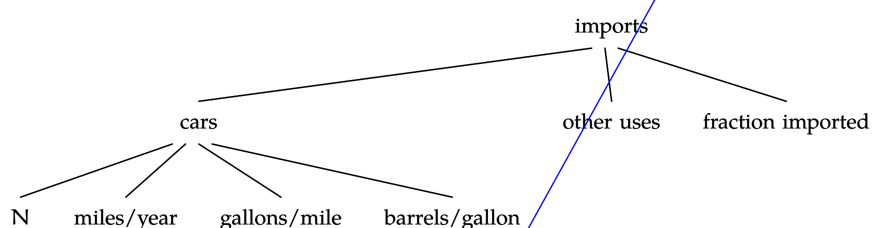

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If I guessed 10000 from the beginning, then compensated for that numbers, that may lead to an even greater deviation. But I guess it all depends on an initial guess. One guess may trickle down and lead to several other possibly erroneous estimates.

I'm also a little hazy on this. How do you decide if your guess is accurate enough to afford adjusting it to compensate for other numbers?

I feel like in this case given that the number of people is an overestimate, lowering the annual miles per car should sort mitigate the errors because they are errors that cancel... but I'm not sure if that was the justification intended for it.

I still feel that I would've begun my guess for miles per year at 10,000 since that is the usual value used for car warranties as advertised by dealers - 5 yr/50,000 mile, etc.

I think making that approximately is fine - we're still on the same order of magnitude, and only off by 1.5x, which for the sake of the estimation is pretty insignificant.

Also, if you think your initial guess is high why not just adjust it instead of potentially introducing more errors on other variables? I know that you can compensate for over estimates in one area by underestimating in others but I dont really understand how this won't lead to compounding or potentially multiplying your errors.

The trick is you don't know if your overestimating or underestimating. At the end of the day, an approximation is an approximation. You can only get so close to the correct answer

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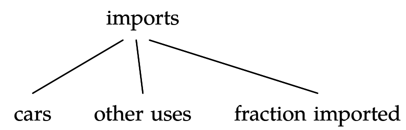

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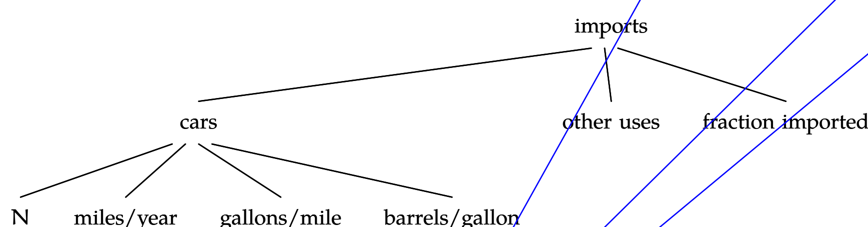

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These seem like good estimates. Most people only own 1 car but some own more and as far as orders of magnitudes go, this would make sense.

I think that estimate is a bit on the high side. I know in the wealthy suburbs, families usually have at least 2-3 cars (though some have 4-5); however, these familes usually have 4-5 members and this is the upper end of middle class. In the poorer parts of Chicago where I used to live, many familes (larger too, given economic conditions) don't even have cars at all. In fact, in cities, even many wealthy people never bother to get cars because it's far too inconvenient. Although rural America >>>> urban America in size, population densities make them about even. So if I were to guess, I'd say maybe 1x10^8.

My estimate does neglect non-consumer vehicles though, like mass transit, delivery, and work vehicles. So if you x2-3, that does you get around 3x10^8.

I agree that the estimate is a bit high, but definitely not more than an order of magnitude so for this class it seems fine.

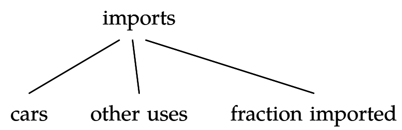
Nevermind, I guess this makes up for the overestimate.

There isn't one number here that I completely disagree with, but I feel as though none of them are really known other than the 3*10^9 people in the US. I'm also still not completely comfortable with trying to manually account for possible errors by making more possible errors.

Accounting for errors with other errors seems to be one of the key ideas in this class, so long as you know in which direction you're erring in.

I agree. accounting for errors by over or underestimating other values seems a little shaky, but sometimes that's the best you can do. if you know you're overestimating something, then you can try to underestimate something else to compensate. obviously, this won't be exact, but after all, this class is about estimating when we don't know how to solve a problem for an exact answer

I found this paragraph a tiny bit dense, just because there are a lot of facts thrown out, a lot of which I didn't know.



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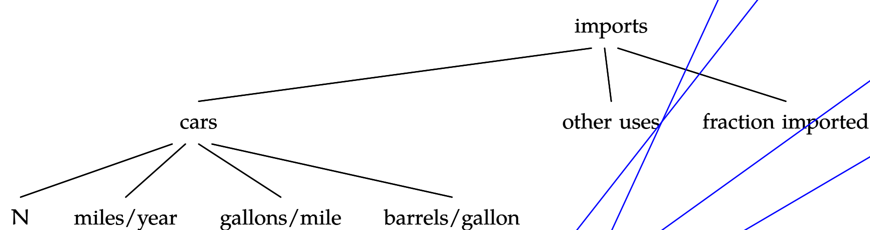

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i know a lot of cars who claim that 25 mpg is "energy efficient" or "above the standard." i would have guessed this number to be lower, especially given america's tendencies towards suv's.

I agree...most cars get usually 18 mpg...its only a new fad that cars are more energy efficient...and most of the cars in the US are used.

Also, I think a lot of driving is done in the city versus freeway....thus the mpg would most likely not crack 20

While I agree this is high, it is not incredibly far off. If you said 20 your off by 20%.

This seems a bit high too. Typical listed mileage might be 25/gallon, but the actual mileage has to be lower.

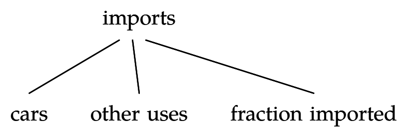
I agree... while we see this numbers like this all over the place in auto ads, these are all hwy millage and not nearly what the average person gets a day. What about guessing the tanks of gas used a week and the average tank size?

that would be _way_ more complicated that you'd want to think about. i'd say 25 is a good estimate...of my family's 4 cars we get 15, 12, 48(hybd suv), & 20...and we drive 3 old junkers.

this answers the question above.

This appears to be a legitimate way to calculate how much a barrel holds...however, the cost that we pay for a gallon of gas is greater than the actual price of a gallon. I don't know how much the price is raised, but it could make a barrel's capacity greater than 40

Good point. Is there any way to actually calculate the premium we pay? It seems that it is a large factor.



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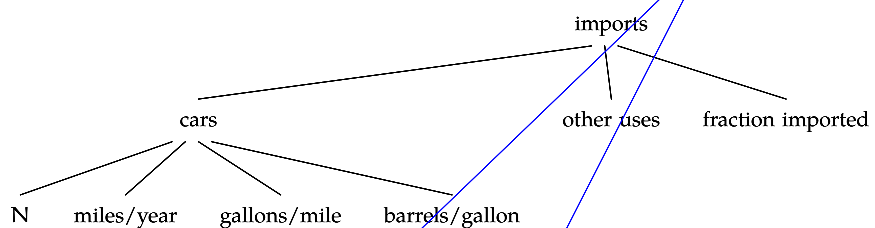

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If the idea of a barrel is similar to that of a trash barrel... the typical drum liners, or trash bags we use in our fraternity are about 50 gallons...making a barrel slightly smaller, which agrees with this estimate of 40.

Yeah, that's more or less how I would have approached this one. It's probably more accurate than my barrel/gas-cost guessing abilities.

I would have had to look up the coast of a barrel, but the other analysis was where I was headed when I first read the question. How come you didn't break up gallons/barrel into another tree - I would've done it that way.

I personally have no intuition about the size of a barrel and could have easily guessed \$1000 for its cost, putting my estimate off by a factor of 10. How do we calculate a reasonable estimate if we are unfamiliar with the units requested?

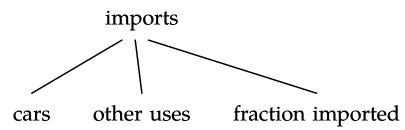
Yeah I had this same problem.

Oil hasn't traded at \$100/barrel in a while - I think \$75 would be a much better estimate given the past few years. However, this is not even an order of magnitude off, so I guess it doesn't matter.

is a barrel the processed oil that we would buy from the pump, or does it have to undergo further processing, raising the price?

I think where some of the confusion comes in here is that there are so many different factors that the estimate has not accounted for, which is ok, since it is just an estimate. For example a barrel of Oil, 42 gallons, only produces about 20 gallons of gasoline after refining, And the fact that the price of a barrel of Oil and the price of a gallon of gasoline can vary so much because of the time delay, refining bottlenecks, and distribution that the fact that the estimates they made turned out close to being correct is either luck, or just good use of averages.

how do we know that a barrel is \$100? I thought that they were more than that



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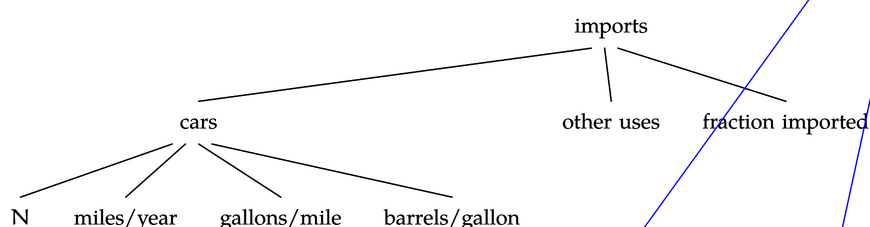

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Interesting fact...the cheapest country with gas prices is Venezuela (where I'm from)....gas is about 0.29 cents a gallon...cheaper than a liter of water.

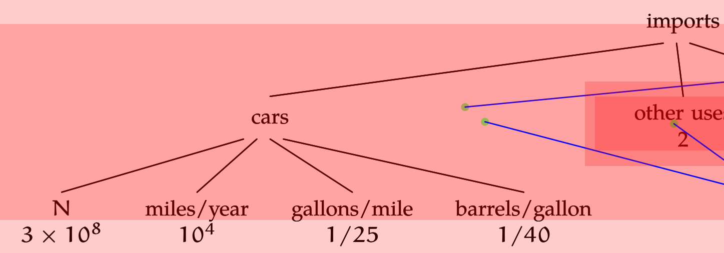
Accounting for the different classes of gas (regular, medium, superior), the price seems like it should be more like \$3.00 and even that might be an underestimate these days.

I think this is more of a wholesale cost rather than consumer cost.

Or perhaps this is just off because of the crazy fluctuations in gas prices in the last few years, but even so the difference shouldn't change the final answer drastically.

Don't the gas companies buy the barrels for less than they sell them for? (Hence making a profit) So estimating this would be an underestimate of the actual amount in a barrel?

Is this a credible price estimate after accounting for fluctuations over time?



All the leaves have values, so I can propagate upward to the root. The main operation is multiplication. For the 'cars' node:

$$3\times10^8\,\text{cars}\times\frac{10^4\,\text{miles}}{1\,\text{car–year}}\times\frac{1\,\text{gallon}}{25\,\text{miles}}\times\frac{1\,\text{barrel}}{40\,\text{gallons}}\sim3\times10^9\,\text{barrels/year}.$$

The two adjustment leaves contribute a factor of $2\times0.5=1$, so the import estimate is

$$3\times10^9\,\text{barrels/year}.$$

For 2006, the true value (from the US Dept of Energy) is 3.7×10^9 barrels/year – only 25 higher than the estimate!

> **Problem 1.5 Midpoints**
> The midpoint on the log scale is also known as the geometric mean. Show that it is never greater than the midpoint on the usual scale (which is also known as the arithmetic mean). Can the two midpoints ever be equal?

1.5 Example 4: The UNIX philosophy

The preceding examples illustrate how divide and conquer enables accurate estimates. An example remote from estimation – the design principles of the UNIX operating system – illustrates the generality of this tool.

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Comments on page 3

Basically, we are going to take the figure from oil and then adjust it. I think the notation is confusing since it does not take adjustment into account

I made a comment earlier about using the gallons consumed by cars and then guessing the fraction that we import. It seems like this method is a little different that originally described

does the proper notation of these trees include numbers or no?

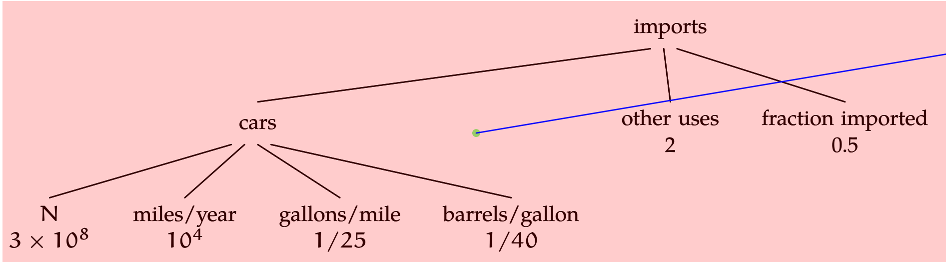
I realize this doubling is discussed in the text, but wouldn't this be better named fraction used by cars? (50%, so we multiply by the reciprocal) Or it could be specified that the branches are equal (cars = other uses). That would make it easier if our redundant method involved calculating the other uses and assuming that cars made up the other half of the total.

Also, if I were to just look at the graph, the way it is worded makes it seem like there are 2 other uses, not that the other uses account for 50% of the total amount used.

so long as you remember that you're starting with a figure for oil used by cars and multiplying it by adjustment factors on the same level leaf. The naming is just to help you remember why that factor is there.

I agree that the notation on the other uses and fraction imported leaves is a little confusing. Indicating operations between the leaves or simply calling them "other use adjustment factor" and "fraction imported adjustment factor" would clarify the units on the figures in these leaves.

Hey, so if we all stopped driving, we wouldn't need foreign oil. Secret to world peace: bicycles.



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This math seems to work out too easily, everything cancels to give 3x10^8 x 10.

There's nothing wrong with that. This is an approximation class and I guess there's an 'art' to it. When you don't have a calculator, it's best to try to break things down into easy numbers w/o losing too much accuracy and the easier you make it for yourself, the faster you can make an estimate.

I agree with the comment above. Why do you feel the math has to be complicated or messy to be right? As we see a few lines down, the estimate derived "too easily" is very close to the actual value, and it didn't take us nearly as much effort as calculating it exactly. While I do agree some things require precision (i.e., anything where lives are at stake), I don't think we should rule out estimation for it being "too easy."

Like in the previous section, I think it would help if the operations were incorporated into the tree. If the paragraphs/text were taken out and one only saw this tree, having the operations would make this diagram much clearer and one can simply use this tree to solve the problem.

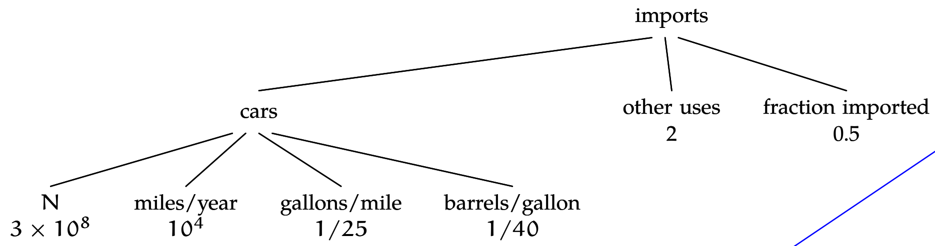
$3x10^11 of oil each year. I thought it would be more.

That's a pretty awesome estimate. For someone who knows about energy, but didn't have any statistics, I would have gone with these numbers: 2*10^8 cars (so 1*10^8) (One car per household, 2 people per household, *2 to include trucks and public transport) avg drive 40 miles a day, 1200 a month, 15000 a year (would have left it at that), would have done down on the mpg; maybe 20 (lots of trucks and older cars), and I would have used 42, but it'd round the same. So I think it's about the same; but that just seemed very elegant.

essentially dimensional analysis is equivalent to the "divide and conquer" method?

huh?

The "car" leaf determined the barrels/year for cars used by households. "Other uses" leaf would consider the number of cars by businesses and "fraction imported" is a rough estimate of how much oil is imported. Luckily 2*0.5=1.



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I don't understand this math. The cars node contributes 3x10^9 barrels per year, but aren't you supposed to just x2 to get total since we estimated above that cars used up about 50% of oil? How are we supposed to tell from the tree that you are supposed to multiply cars, other uses, and fraction imported?

Just multiplying the cars consumption by two gets us the estimation for all the oil used in the US, but we decided that 50% is made in the US, thus not imported. We are trying to find the total imported, so we only want half of the oil used in the US.

Clearly, it is best to assume half the oil usage is not automobiles but it could be that more is imported then we took into account.

I don't really understand what just happened hear. How do the "adjustment factors affect imports? Does the two represent the denominator of a fraction and if so what is the denominator for cars? 1?

We've found how many barrels of oil cars use each year but that's still only part of the tree. We said that cars are only 1/2 of the oil consumption so we have to multiply our value by 2 and then 1/2 of it is imported so we multiply by a 1/2 as well. These factors cancel out to 1.

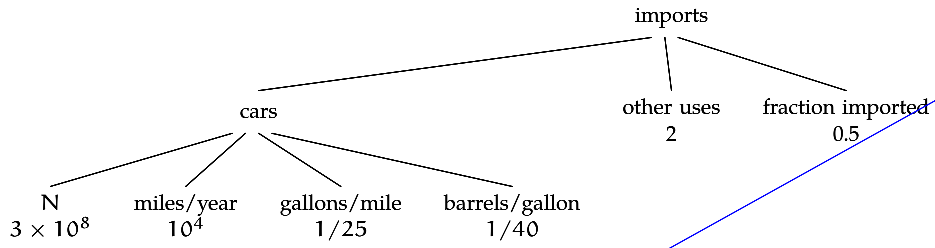
It's kinda funny how leaving things out or including them ends up just about the same.

So maybe this is just me being not very proficient at estimating, but sometimes I get the feeling like this text looks at a statistic and works backwards to make its estimation somewhat accurate.

I get that feeling too. But maybe Sanjoy has just done so many estimation problems that he can pick better numbers than we can. Some of these numbers like US population, gallons/mile, etc. are learned through time and the more experience you have with these sorts of problems, the more realistic you'll be when you guess.

I sometimes feel that way too - the estimates are just too close. Even for an experienced estimator, you would expect to be off by an order of magnitude or so every once in a while. He is however, extremely good at estimating, so it's possible he's developed an intuition for what kind of answer "feels" right.

is there a way to calculate uncertainty or is that just a confidence interval that we think? do we make a separate tree of uncertainty intervals



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Before the oil crisis of 08! People were taking about 200$ a barrel and gas prices at 4.5...which is on average the prices in Europe (they are so much higher than the US)

And, as an interesting note....interest in removing oil from shales in the midwest, which requires using an extraordinary amount of energy to heat the rock up to release the oil (one suggestion, a prof from MIT, was to use nuclear power....)

So our answer is really close, but it would be interesting to know why. Is it possible to, in hindsight, say these particular estimations were bang on, these were too low and these were too high, but here's where the errors canceled? Is that data available?

Well, I'm sure statistics are available on oil use in the different areas (especially manufacturing). I'd guess that a decent amount of error results from our assumption of 50% imports, since I think I've read and heard something closer to 60% (which would give us 3.6 instead of 3, which is almost spot on)

Yeah, thats true. I also had read that roughly 2/3 of the oil was imported. When I did the calculation though I got 4*10^p which wasn't so far off.

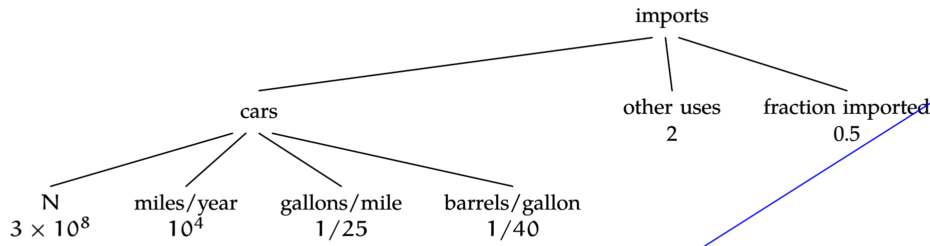
I feel like if I did this estimating, I would be very off.

It would be cool here to include the actual values of some of the actual factors we estimated, like the number of cars and amount imported.

I think the whole purpose was to show a basic estimate with accurate results. This shows how we are able to simply the problem without knowing additional facts. Comparing those numbers to actual values of "other uses" and "fraction imported" does not really contribute to the topic.

this should be 25% higher

I'm curious: what fraction of your estimates end up elegantly close to the actual value? Awaiting the mantissas...



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typo: should read 25%

How close do we want our estimates to try to be? I guess it's within an order of magnitude, but 25% does seem like a lot compared to some of the stuff we were doing in class, where we got less error (although I guess we also got some guesses that were probably around 25% off or more...)

I feel like with many approximations, the idea is to get within an order of magnitude. In this case, 3 versus 3.7 is pretty darn close.

i agree, this is a close number. it helps when you know what it is before you begin however ;)

It is within an order of magnitude, but still, 25% seems like a pretty big margin of error...

isn't 25% a significant error?

You mean 25% higher, as opposed to 25 higher

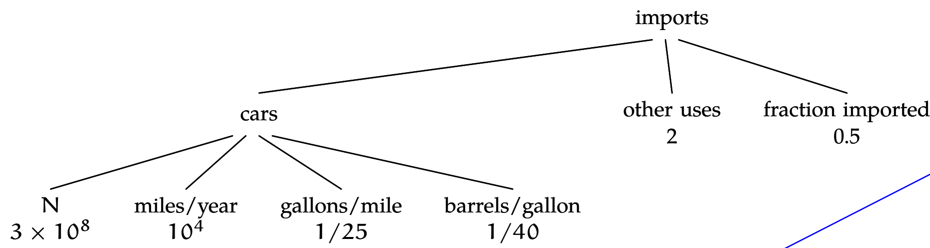
but even though it's 25% higher, it's still a good estimate, as we want to look at orders of magnitude. obviously when we multiply by powers of 10, a small error in our estimate becomes amplified. but this is still a good estimate here. we got in the right ballpark: the real value is 3.7 billion, when our estimate was 3 billion (at least we didn't guess something like 3 million)

This seems completely random. We know that we are somewhat working on a log scale because of "few" but why does this belong here? Just to do a proof?

I agree, this "concept question" seems out of the blue and not obviously relevant to the previous example.

This does seem out of place. I think it would have made much more sense if it was placed with the initial discussion of "few".

How is this related to our tree diagrams? I would show that...using log does it have something to do with the quantity of e



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this problem was so much simpler! i think it was really good for more practice...it wouldnt have been very good for teaching though–I really like the complexity of the previous one (and the ability to verify different parts).........[there should be line breaks in nb].......I was thinking that it would probably be a good idea to have sidebars in the final text. you see them a lot in math/science texts, include general information about the assumption, like what a pit is or what sampling rates are.

this makes no sense to me

What is the log scale, and how do we calculate the geometric mean?

The geometric mean of 2 numbers n and m is the square root of their product.

GeoMean=sqrt(n*m)

The standard scale would be 1,2,3,4,etc. Using a base of 10, the log scale would be 10^1,10^2,10^3, etc... See http://en.wikipedia.org/wiki/Log_scale for more info. http://en.wikipedia for page on geometric mean (or see the answer in the other comment. I'm unclear how the problem relates the the previous example, it seems somewhat random.

thanks! this helped me too

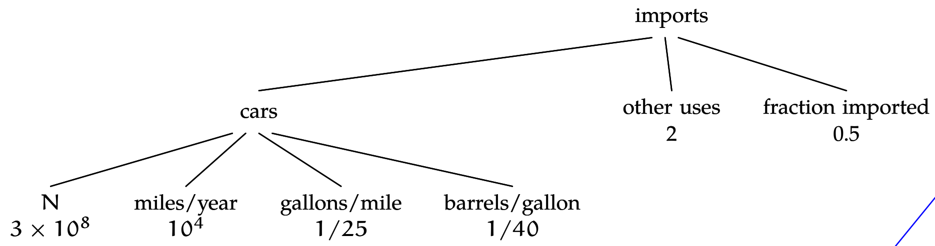
i dont quite understand how this fits in with the previous section. i dont see how it is an estimation problem either.

Perhaps you can elaborate. In the last section we discovered trees. In this section we used the tree method to estimate something. Do you think this estimate is to obvious?

In the beginning it said that we would subtract for the oil produced in the US, did we decide to neglect it? I didn't see that addressed in the estimation.

That's the "fraction imported" node. I don't think this was clear to very many people. I think a different node name, even simply "fraction of oil produced in US" then multiplying by the 1-(this fraction) might even be better.

'usual scale' seems a little vague since we are talking about geometric mean on log scale. Is 'linear scale' too confusing? Or 'usual, linear scale'?



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Yes. They are always equal when the two numbers are the same. To prove this, set 2sqrt(nm)=n+m. Any n and m that satisfy this equation will have the two means be equal. The only n and m combinations that solve this have n=m

I found Problem 1.5 confusing. Both scales go up to infinity. So: what does "the midpoint on the log scale" denote? Are we talking about the midpoint of a line segment, measured on a log scale?

I think its talking about the idea that we have talked about in class for the number 10, for the geometric mean we use 3, but the midpoint on the usual scale is 5.5 (halfway between 1-10).

also, I'd switch 1.2 & 1.3 (keeping the same problem & using a side bar)...then you'd have the trees to help with the multiple estimation parts

i feel like this would've been an easier example to start with than CDs, because it requires numbers and intuition that more people are familiar with. the details of how CD data storage works seems a little esoteric to me...

yeah I agree, this example is a lot easier to follow and I have a better grasp of divide and conquer now.

I agree also, I like this example better than the CD. I feel like you need a certain amount of technical expertise to understand the CD example, but not with this one. I think this example could be more beneficial to more people.

i also agree, capacity seems a lot more vague than oil and this has less methods of calculation so it's a simpler example to start with (whereas the cd used many different approximations)