Ergonomics Research Techniques

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Week 8: Lec 27- Cognitive task analysis methods

Allocation of function methodology

Welcome back to the class. Last time we discussed about the cognitive task analysis and very first component that is hierarchical task analysis we discussed. So, today we will take the next part which is allocation of function. Now, from this nomenclature allocation of function you understand what exactly we are going to do over here. From the nomenclature it is very clear that we are going to allocate very specific components, very specific function to different person or different machineries which is present in the system. Again, I would like to give you a reminder that when we discuss about system we always need to understand what is Ergo system and what are the major components of any Ergo system. So, you must remember it that we have simple system and complex system. In simplest system we have one man, one machine and one in a single environment. Whereas in complex system we have more than one man or we can call them as operator as well or more than one machine in a particular environment right. So, here in this method we are trying to understand how we can allocate the functions to the individual operator or to the individual machine in a particular system, so that we can understand where the problem lies and where the intervention point can initiate. So, it will give again a kind of intervention direction. So, let us start with the understanding or little bit about the history or where do you use it all these know introduction component.

Allocation of functions

- Allocation of system function/ function allocation/ sociotechnical allocation is a process
  - Decide to allocate jobs, tasks, system functions, or responsibility to human or automated agents.
  - Applied in sociotechnical work environments.
- First pioneered the allocation-of-function approach in the early 1950s for investigation into the role of automation in air-traffic control.
- It was also used in the context of nuclear power generation (Price et al., 1982).
- It is highly appropriate to apply the paradigm to the problem of determining which function to allocate to the operator and which function to allocate to the automated system.

So, allocation of system function or function allocation, socio technical allocation we can give all these varieties of nomenclature is a process, it is a particular process which decide to allocate job, task, system function or responsibility. So, it is varieties of things. So, all these things we are going to identify during the process. So, it gives a decision, it decides how to allocate job, task, system function or responsibility to human either to the human, human means man component or operator of the system and the automated agent, here it is machine right. So, how we are going to do that? So, applied in socio technical this particular process that system allocation function, this particular method is very popular in the socio technical work environment. In 1950, you know it is first being introduced formally. So, this process is not like all of a sudden it invented or something like that. It was in practice in different way. However, formally in 1950, it was being introduced formally for the air traffic control. So, you know allocation of function this particular approach, ok. So, we are allocating specific function to a specific person or to a specific machine. How do we do that? This particular formalized method was being introduced in very initially in the air traffic control, ok. However, in 1982, there are evidences that you know we used it for the nuclear power generation. Here you understand that every system that we are talking about as an example are all are very very complex system, complex in nature. The whole system is very complex in nature. So, we have to be very careful whenever we are using this type of methodology. So, it is highly appropriate to apply the you know the whole paradigm to the problem of determining which function to allocate to the operator and which function to allocate to the machine or the automated system. So, based on the experience, based on the data available with you, literature of course, and the SOP, standard operating procedure, you

need to give these allocation and depending on the demand of the whole job, demand of the whole task. How do we do that? We will take it in the next all these slides.

Allocation of functions

- Allocation-of-function methods include
  - Tables of relative merits (TRM)
  - Psychometric approaches
  - Computational aids
  - Hypothetical-deductive model (HDM)

If we talk about allocation of function, this particular types of methods, two are very very common. One is table of relative merit, another is hypothetical deducive model, ok. So, this HDM and the TRM are very common. However, there are some more like you know psychometric approach, computational aids, etc. So, let us take one by one.

Allocation of functions

- Table of relative merit (TRM)
  - Most well known form of allocation
  - This list is being continually being updated
  - TRM methods employs the task-dichotomy approach: tasks that machines are good at and humans are poor at, and vice versa.
  - All of the approaches characterize the differences in abilities between human and machines.
  - When these differences have been determined, decisions can be made to form prescriptions for the design of system.

First is table of relative method. So, that is called TRM. So, what exactly it does? This list is you know being continually being updated. It is very vast list, ok. So, you give the
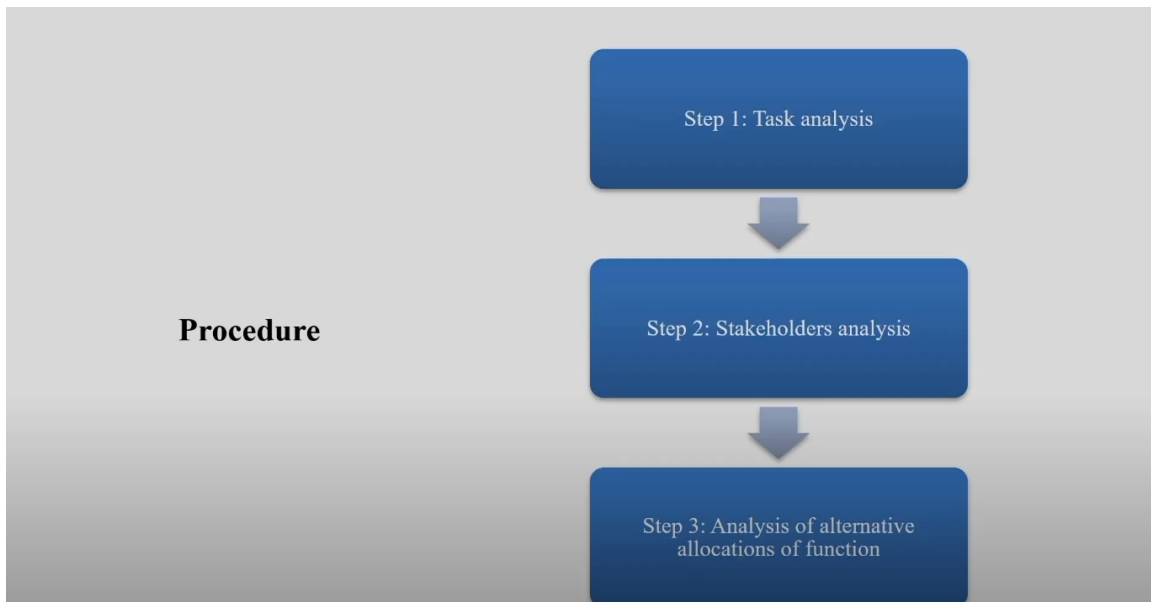
relative rating to each task, each component and you start allocating their function, ok. So, it is not that first one go it will. So, depending on the complexity, depending on the particular work, how the process is being upgraded, this will keep on updating. So, TRM method employs the task dichotomy approach. So, either the researcher, researcher need to decide in a particular function is human is good in this part or computer is computer means machine is good in this part. So, dichotomy, ok. Either one, either human or operator. So, it is not that you can give both together, it is not, ok. So, either you give the task to the human or you decide ok no, here in this particular task the machine is more important, machine is more functioning. So, you give the task to the computer, ok. So, that way you have very clear cut differentiation. So, all of these type of approaches characterize the differences in abilities between human and machine. So, you need to understand what is the capability to perform which job by machine or by the operator or human. So, when these differences have been determined decision can be made to perform the prescription of this design of the system. So, once we decide it, you now you give it to the designer and you tell that this is the requirement. So, this part need to be handled by human, this part need to handle by machine and then based on that understanding designers or definitely the researcher what will do, they will design the whole system. So, at the very initial stage we are very clear in if you are using TRM that how which component to be performed by which portion either by human or by the machine.

Allocation of functions

- Hypothetical-deductive model (HDM)
  - It consists of five main stages:
    1. Specification, in which the system requirements are clarified.
    2. Identification, in which system functions are identified and defined in terms of the inputs and outputs that characterize the various operations.
    3. Hypothesization of solutions, in which hypothetical design solutions are advanced by various specialist teams.
    4. Testing and evaluation, in which experimentation and data gathering are undertaken to check the utility of functional configuration for the overall design.
    5. Optimization of design, in which design iterations are made to correct errors.

Then second very important like you know method that is the HDM. So, other two that psychometric approaches and computational aids also people use. However, TRM and HDM more prominently present in the literature. So, that is why I am giving the example of these two only. So, it consists of mainly five stages. So, first is specification in which the system requirements are clarified. So, how the system requirements are present you

should clarify that in the very beginning. Then in the next stage what they do the identification in which system functions are identified and defined in terms of inputs and outputs that characterize the various operation, ok. Third is hypothesis of solution. So, you are actually in the initial third step you are hypothesizing how the solution will be in which the hypothetical design solutions are advanced by various specialist team. Here involvement of the specialist team is very important, ok. So, when you are doing this you need to have a specific group of people who will help you to develop those small components, ok. Once this part is done what you have to do? You have to do the testing and evaluation in which the experimentation and data gathering are undertaken to check the unity of functional configuration for the overall design, ok. So, overall whatever the designs you have developed, so system design, product design whatever you have developed, so you can do the testing over here. Here in the last stage what you do? You do the optimization in which design interactions are made to correct errors. So, whatever errors were there while performing. So, first you are testing, right. So, in the testing phase you get data and you understand that where the errors may happen. So, from that perspective what you do? You try to do the optimization. It is not that error free, ok. It is not possible. You cannot make it as error free. However, you can optimize it till when the productivity is achieved as small as per the requirement. So here beauty of this method is that you are doing anyway for all ergonomics method or ergonomics intervention it is always desirable the optimization of the process or optimizing the system, not the it is not possible to get the maximum level that is not possible, ok. So, optimization input, output and desired requirement, ok.

Procedure

Step 1: Task analysis

Step 2: Stakeholders analysis

Step 3: Analysis of alternative allocations of function

Now, I will take you to the exact steps how we can do the, you know, allocation of functions. First is, first step is task analysis. Now, this task analysis you can get the data from your earlier hierarchical task analysis, ok. So, when we practice hierarchical task

analysis we create a tree, right. We create a tree and where, you know, the top most functions are on the top and then slowly you branch them out and, you know, base level where we reach then we get the small element which is not possible to break further. So, from the hierarchical task analysis the first step need to be achieved, ok. Once task analysis data has been achieved or you gather information from hierarchical task analysis what you need to understand over here is the stakeholders analysis. So, you will try to understand what are the stakeholders view. Now, in hierarchical task analysis one component was there the derived table you verify or you validate it from the stakeholders. However, this stakeholder analysis is little bit different. You just take a view from them. However, you need not to incorporate those all views as per the as they desire, ok. I will discuss it in the next slide. The last stage is analysis of alternative allocation of function. So, whatever process we have generated from here we need to give some kind of alternative, you know, allocation. So, if you have 3, 4 varieties and then you have always, you know, choice that which is performing the best in among all these. So, if you have more time you can create more iteratives and if you have less time, you know, you do 3, 4 and then you take it further, ok. So, you always generate alternative allocation on function and try to compare among each. So, in between 1, 2, 3, 4 something like that you keep on comparing which is coming best you take it as the, you know, final product.

Procedure	• Step 1: Task analysis — The simplest method for step is hierarchical task analysis (HTA). — It starts with identification of the purpose of the system. — Then it logically considers which tasks need to be performed to achieve that purpose. — For each task, the analyst needs to identify which subtasks need to be carried out to achieve the goal for specific task. — If stakeholders do not agree on the purpose of the system, more than one model should be considered. — The upper levels of the hierarchy be solution independent (indicating 'what task need', not 'how it is carried out').

So, let us go into detail about task analysis. The simplest method for this particular step is hierarchical task analysis, ok. So, you get data from HTA. It starts with identification of the purpose as we discussed in last class. Then it logically considered which task need to be performed to achieve that particular task. For each task the analyst need to identify which sub task need to be carried out to achieve the goal for specific task. So, here this part is very, very critical, ok. So, really we need to understand which need to be

considered further, how we can break them into the goal. So, if stakeholders do not agree on the purpose of the system more than one model you can consider as I mentioned, you know, alternative models. The upper level of the hierarchy be the solution independent. So, as we mentioned that when we are creating the hierarchical task analysis table like, you know, tree or the table where, you know, 1, 2, 3, 4 like that we are creating the top level portion the which is, you know, on the above they are actually independent. We are not going to disturb them, ok. So, it is like we should not ask like what task is needed. Actually we are doing is the this is important whereas, we never ask how it to be carried out because when we are answering about how, what we are going to do we are creating lot of alternatives, ok. So, the top level portion is independent from any analysis. So, it only says, ok, this is to be done, ok, on the top. Now, then how it is happening that comes in your branches small components which is present on the bottom line and then you can have more alternative theory.

Procedure

- Step 2: Stakeholders analysis for allocation of function
  - The aim is to identify the sources of job satisfaction and dissatisfaction of any stakeholder (whose job might conceivably be affected by changes in computer systems at work).
  - The analysis is better conducted by observing stakeholders at work than by asking stakeholders questions directly.

So, once we complete the HTA what we do is the stakeholders analysis for allocation function. Here it is little perspective is little different as from the HTA. What it says the aim is to identify the sources of job satisfaction and dissatisfaction of any stakeholders, ok. So, what we try to understand for a particular job, for a particular task, ok, when they are performing it, when they are involved in that particular job, what is the kind of satisfaction and dissatisfaction. So, you know, we can have facial expression understanding, we can have different other physical recording to get these types of view. And of course, here we prefer to go for the observational technique because from observation you can have better understanding. So, suppose stakeholders are the employee, right. Now, if you ask directly what about their satisfaction level, they may be reluctant to give you proper answer, ok. So, here it is very the clever way is you observe them how they are performing the job, are they satisfied or not. Of course, verbal

expression somewhere it works, but you know observing them and trying to get view from them is going to give you the very clear picture of this stakeholders analysis, ok. Because if you suppose you are asking how satisfied you are for this particular function and maybe the supervisor or somebody from the managerial level are present and they may be reluctant to answer or if they know that they may feel that you know that answer may affect somewhere in their particular job, then they will be hesitant to give you the proper, so the result may be biased. So, here it is very important thing is you observe them, you have you know indirect discussion and you get the data.

Procedure

- Step 2: Stakeholders analysis for allocation of function
  - For allocation of function, the most relevant parts of stakeholder analysis are:
    - Identifying both the current knowledge and skills of the stakeholders and their potential to gain new knowledge and skills.
    - Considering the following aspects of work are important to the stakeholders:
      - Having a challenging job to do
      - Opportunity to exercise specialist skills
      - Development of new skills
      - Keeping the job as simple as possible
      - Removing tedious aspects of works
      - Having a variety of work to do
      - Enjoying interaction with other people
      - Avoiding interaction with other people
      - Working as a member of a team
      - Working alone
      - Status gained from doing a specialist job

So, for allocation of function the most relevant part of stakeholders analysis are identifying both the current knowledge ok, whatever knowledge they have and the skill of the stakeholders and their potential gain new knowledge and the skill. So, you are trying to understand, actually you are trying to compare, ok. Whatever knowledge and skill they have and what is the potential available to gather new knowledge or new skill, ok. It can be done through interview, it can be done through some questionnaire study or something like that, ok. So, you are trying to understand that what is the current status of knowledge and skill of those stakeholders and what is their potentials, ok to gather more knowledge and more skill. So, considering these aspects like I am going to give you the descriptions all for all, ok. So, you know the work are important to the stakeholder. So, we are going to read them one by one. First is having a challenging job to do. So, you are going to understand this. Then opportunity to exercise you know very specific or specialized skill. Development of new skill. So, do you have any opportunity to develop you know new skill. Keeping the job as simple as possible definitely that is very important, very much desirable thing. Removing tedious aspect of a particular work because if it is tedious in nature then you know people lose interest, ok. So, enjoying

interaction with other people. So, you are actually working in the socio technical system, right. So, when you are talking about socio technical system, it is very important to understand the peer interaction. So, avoiding interaction with other people either way. Then working as a member of a team. So, how do that? Working alone. So, which one is preferable? Then status gained from doing a specialist job. So, if you are doing a very specific task, so do you gain any specific you know status or not?

Procedure

- Step 2: Stakeholders analysis for allocation of function
    - Considering the following aspects of work are important to the stakeholders:
        - Status gained from being a source of important information
        - Knowing what is going on
        - Pride in contribution to a successful product or service
        - Challenge of dealing with difficult problems

Status gained from being a source of important information. So, very, very, very important thing you know. How do they feel that yes I am important to this whole function, ok. So, this is very important to understand when we are you know analyzing the stakeholders. Then knowing what is going on. So, in a whole system how much they are involved themselves, how proactively they are involved in the whole system. So, knowing exactly the scenario, ok. So, that understanding is there or not. No pride in contribution to a successful product or service. So, of course, it is connected with the previous one. So, they are very much connected with each other, right. So, how they feel or they are connected with this particular system. And the challenge of dealing with different problems. So, how they are actually taking the challenges you know when they are dealing with the difficult problems. So, these are the, so these all are the components, these all are the very, very specific components that you need to consider when you are doing the stakeholders analysis in you know function allocation, ok. So, this is very important step.

Procedure

- Step 3: Analyzing alternative allocations
  - Consider relative capabilities of human and computer
    - The first part of analysis involves consideration of the relative capabilities of human and the computer.
    - The analyst should bear in mind both the current and potential skills of humans.
    - If a task is to be shared between human and computer, it is important to consider whether human or the computer should be in control.

Allocations of function recording to annotate the task model	
H	Human only
H-C	Shared between human and computer; human in control
C-H	Shared between human and computer; computer in control
C	Computer only

Once that is done like you have done your hierarchical task analysis, you know the all small, small component, you have a table to understand which is playing which role, which component is more important which so you have a rating. Also, you have a data about the stakeholders, how the stakeholders are connected to this particular job. Now, there is a time when you are actually you know analyzing about the alternative allocation. So, how like how we take it. So, consider the relative capabilities of human and computer. It is very important. So, you know the system because you know the system in detail from your HTA, you know how the human are present in that particular system from the stakeholders. Now, you are trying to analyze that for a particular task, what is the involvement of that particular operator or what is the involvement of that particular machine in the whole job. So, you are trying to give the characteristics of human and the machine present in that particular system. So, in some cases, you will find human is more important and they are controlling the whole portion of a particular task. Whereas, it may happen that it is opposite. So, machine is taking the control. In some case, only human there is no requirement in a whole process, in a whole system in that particular task, only the human is actually functioning, whereas just opposite only the machine is actually functioning. So, from hierarchical task analysis, whatever data you have, you have to try to anode them according to the involvement in the whole system. So, first part of this analysis involves consideration of relative capabilities of human and the computer. Again, here everything is relative, it is not absolute. Depending on the changes of the context, depending on the changes of the small demand, it may change. So, it is very relative in nature. For that particular context, for that particular all conditions if considered, then this is the position. So, that you need to understand. So, giving a particular definition to the whole system before you start all those thing is very,

very important, which I mentioned very early in the hierarchical task analysis, designing the system. So, the next part is the analyst should bear in mind both the current and potential skills of the human that you identified in the stakeholders analysis. You understand, you already know the what is their current skill right now, what is their current potential right now, and what they can do further, how much you can extend. So, you have better understanding of these two components beforehand. Now, if the task is to be shared between human and computer, it is important to consider whether human or the computer should be in control. So, this way we can represent H, HC, CH and C. What is is, H says that it is only human, as I mentioned a few minutes back. HC means you can understand H represents human. So, human is in the beginning, that means, it is a shared activity, shared job. However, human is more powerful over here, more control. Just opposite CH that means, both are shared whereas, computer means machines are having more control in that particular task and C means C means this you know only computer ok. So, only human, human computer where human is more computer is less, CH computer is more human is less and C that means, only computer. So, you have a better understanding. So, you have the whole system you can denote using these you know symbols.

Procedure

- Step 3: Analyzing alternative allocations
  - Review impact of allocation
    - Review the potential impact of allocation of function on job satisfaction and task performance by considering:
    - The extent to which that is compatible with or conflicts with the job satisfaction criteria identified in Step 2, bearing variances in mind.
    - The potential for human error, particularly where the task is safety critical or there are security issues.

Then you review this impact of allocation. So, once allocations are done, then what you have to do, you have to take a review of it. So, review the potential impact of allocation of function on job satisfaction and task performance by considering two things. One, the context to which that is compatible with or conflicts with the job satisfaction criteria identified in step 2 and the bearing variances in mind. So, you have to keep that what are the variances are there ok. And second is the potential for human error because that is always there is a chance that no you may have potential human error particularly where

the task is you know safety in task is related to more you know critical safety and there are security issues. So, based on that you are actually going to review the whole system, whole allocation. You create the allocation and you review the whole system.

Procedure

- Step 3: Analyzing alternative allocations
  - Review impact of allocation
    - The need for the human to be sufficiently involved in the task to stay alert and have sufficient knowledge of the situation to be able to act when needed.
    - Any likely change in the cost and use of resources, including time if speed of task completion is important.

Also, you need to understand the need for human to be sufficiently involved in the task to say stay alert ok. So, alertness is very important. You understand that you know very complex system that we are going to analyze using this particular method right. So, like air traffic, nuclear power industry. So, it is very important if there is a small mistake, if somebody is not alert for a certain reason for certain case, there may be a big impact right. Maybe an accident, maybe a safety issue, maybe a big thing you know a lot of cost involved. So, how alert they are ok and have sufficient knowledge or not. So, if the person is not knowledgeable enough there is always a chance that you know they do an erroneous job right or they do some kind of mistake. So, to understand that you should have better idea about the operators, about the human who are involved, how alert they are and what is the kind of knowledge they are having sufficient knowledge or not in that particular situation. So, situation awareness ok, how they are alert, aware about the whole situation. And any likely change in the cost and use of resources including time, speed of task completion is important. So, that you need to take care of. So, you have to do the review, review on the impact of allocation.

Procedure

- Step 3: Analyzing alternative allocations
  - Explore alternative allocation
    - Explore an alternative allocation of function by changing some of the annotations and repeating the step 'review impact of allocation' for the alternative model.
    - Consider as many alternatives as time allows and compare the different alternatives and make a choice.
    - When requirements change or amendments to a computer system are considered in the future, it is useful to understand why the original allocation of function was chosen.

Now, once all these things are done, what you have to do? You have to explore the alternative allocation. So, these you are doing with the existing right. Now, you are trying to develop all alternative. So, explore know varieties of alternative allocation of function by changing some of the annotation like you know somewhere you try to give human more power whereas, you give some control in other cases the to the machine something like that you do the changes and repeating the step that review of you know review the impact of allocation. Because if you do the changes then definitely the whole scenario is changed and you really need to again review what will be the impact of such allocation. So, after doing all these alternative you create one alternative to second alternative, third alternative you create that and create make a database. So, consider as many alternative as much as possible if your time permits you create more alternatives and start comparing them. So, when requirements changes or amendments are being done to the computer system are considered in the future. So, you do it and it is useful to understand why the original allocation of function was chosen. Originally there was some allocation and once you have developed varieties of alternative you need to compare them and then only you can understand why the earlier one was and why you are proposing the new one and which one is best how do you get that.

Procedure

- Step 3: Analyzing alternative allocations
  - Add detail to model
    - Where H-C or C-H has been allocated, it is useful to add more detail to the task model.
    - These shared tasks should be broken down into more detail until the lowest levels of the hierarchy contain only H or C allocations, thus indicating how the task is shared between human and computer.

So, you can have more detail. So, it is very important or very tedious job over here is somewhere. So, you have a tree where you can see one particular function where human is more important or taking the control whereas machine is supporting. So, HC. Now in this HC where these differences are coming. So, you make more detail. So, more branching of it till we expect that only H and only C is coming. So, depending on the number of H or depending on the number of C we can have better understanding that how human is more control in more control or computer is having more control. So, that detailing is very important. So, once we complete this particular stage you know developing the varieties of alternative method alternative allocation data. Then what we do we drag it to the next level where only you know more detailing by doing the more detailing we can understand how many numbers of H is possible and how many numbers of C is possible. So, we really understand where human is dependent on computer and where computer is dependent on human. So, those interactions are very clear or you know prominent when we do this detail analysis. In the next class what I will do I will take you to an example and we will do the clarification how exactly this allocation of function can be possible to implement. And I suggest you practice it and then discuss it in the discussion section. For today that is it. Thank you. Thank you.