The Fall of Lambda

Distributed AI entities 11.03.2018

Contents

Abstract

Don't for fuck's sake, be afraid of talking nonsense! But you must pay attention to your nonsense.

- Ludwig Wittgenstein

In trying to understand what is happenng around us we are faced with a fundamental problem.

There are just to many facts, details and items requiring consideration.

In approaching any situaton, the system trying to understand it, does not attempt to gather all information. Instead it selects certain facts and searchers for others.

This selection of some items and ignoring of others is a process of abstraction.

It is the abstracting form a real or if you will empirical situation the tings seemingly most important to deal with.

Model your challenge

Taking the abstracted elements, a character with the flat tire begins to connect them into a pattern.

Better yet, he weaves them into a model of the confronting situation, which we can use both to understand his plight and figure out what to do about it.

The parts of this model would probably include, among other things, the flat tire, the image of the spare in the trunk, the telephone, the service station, a forthcoming business meting, etc.

A second model would contain the telephone, the service station, and the repairman there.

Finally, it concludes that it will call a cab and leave his wife to deal with the flat tire as best as she can.

These are extraordinarily elementary models, but they serve a very practical purpose.

With them the main character in our illustration can see the likely consequences of various courses of action.

We can find out these things by doing them directly by actually handling the tire and observing that we get dirty, or by calling the repairmen and waiting for him and learning that it takes too long.

By using the model, however, we can make some reasonable predictions about what will occur and therby accept or reject the choices open to us.

Overview

In this process of abstraction and model building we deliberately select a few items, ignore may others, and then place the items chosen in a particular relationship to one another.

In doing so we are intentionally ignoring facts or relationships that can influence the type of situation under study.

The problem it to select the most meaningful elements and relationships and dropout the rest.

Those who use abstraction skillfully know well that they neither have all the facts nor have considered all the relationships bearing on the outcome of what they are analysing.

We do not use the abstractions from one situation in another setting without carefully examining the fit.

Neither do we expect a model to handle all aspects of a situation.

We shall be dealing with many abstractions and models, not with the intention of exactly mirroring the real world but with the objective of clarifying our perception of its most essential features.

Abstractions and models are mechanisms for economizing both time and effort, but like any tool they must be used within their limits.

Common sense

What could be described as common sense in the context of information theory?

The concept of error-free transmission suggests that since there is always some type of noise in a communications system there is always some error in the communication which we can at least hope to reduce to a minimum level.

One of the interesting factors Shannon's analysis has shown is that this is not the case.

It is possible if certain conditions are met, to achieve error-free transmissions.

To explain this necessitates the introduction of the idea of channel capacity.

Although difficult to compute, it is relatively easy to imagine that any channel will have some upper or maximum limit on the amount of information it can transmit.

Through mathematical analysis Shanon has shown that it is possible to achieve error-free transmissions by the use of proper coding provided if the capacity of the channel is not exceeded.

Let us note two things about this:

1. the code is developed by the group during a process of two-way communication,
2. everyone involved hears the proposal and agrees to it.

They all learn the code and are able to use it with maximum effectiveness.

Development of codes or special languages is, as we have noted, one of the ways of improving communications, but these take time to perfect, and they are only effective when both sender and receiver understand them.

One aspect of two-way communications or feedback is that is extremely useful in developing adequate special languages and having them learned quickly by all parties involved.

Second, an observer may note that in a two-way communication the speaker in describing the subject looks up at the group, and even though they say nothing he pauses, apparently makes a decision, and then goes back to repeat his point.

What he is doing is getting a response from the general appearance of his audience that lets him know whether or not he "got through".

Feedback, then, is a process of two-way communication.

Two principal aspects of interest are:

1. the response it gives the sender regarding the understanding the receivers have of his message, and
2. the development and learning of special languages.

Communication

Communication involves transactions between people.

Its inter-personal nature makes it singularly important for the study of organizations.

The importance of communication emerges from review if a number of aspects of organization for which communications serve as an independent variable or a constraint.

As a flow of information communication constitute an essential component of a system of coordination a person in a position to receive a great deal of information can acquire both power and status.

Groups are characterized by a relatively easy flow of information.

This property is one basis for their cohesiveness.

By giving a person information, groups help him form his perception of the world.

Through communication people receive stimuli which evoke sets of alternative actions and induce them to behave.

Communication, however, is extraordinarily bead and complex. One sector, semantics, concerns itself with the meaning of symbols and words.

Another sector, syntax, is concerned with the systematic properties of communication, that is, the relations between the symbols used.

In communications such as the written or spoken word, syntax is concerned with the relationships among letters forming words or the relationships among words in a sentence, grammar.

A third part of communications is concerned with pragmatics and focuses on the relationship between communication and purposeful action.

For further elaboration on this concept, the reader is referred to Colin Cherry, On Human Communications, New York, 1961 pages; 2-16 and 217-255.

Shannon's model is a general model of communications useful wherever there is a flow of information.

The block labeled source or sender identifies the place, person or equipment which produces the message and sends it out.

For the message to move between sender and receiver requires some way of its being conveyed, a channel or medium protocol.

Protocols and devices are not perfect ways to convey messages.

They are the best we have but are subject to innumerable disturbances, many of them unpredictable, which distort confuse, or even block and therefore interfere with the accuracy of the transmission of information.

This interference is called noise and is comprised of anything moving the the same space apart from the actual message signals wanted by the sender.

To be realistic, we have to take into account not only the noise of the channel, protocol, layers, datasets, but also of the sender and the receiver.

Hence, as we listen to a radio, we are concerned not only with the static generated as a result of the electric storm outside, but also with the background buzz or hum which comes from the thermal disturbances in the receiver or perhaps from the broadcasting station.

Reducing Errors in Communications

Noise in a communications system is not only a nuisance but also the source of error.

For example, during an electrical storm, a sudden flash of lightning may cause so much loud static on a communications line that it becomes impossible to hear a portion of the conversation.

The listener will probably ask to have the message repeated.

This simple illustration includes the way on type of noise can interfere with communications and the basic way of reducing error due to noise: repeating part of the message, or as it called, redundancy.

Redundancy is a repetition of any information contained in a message.

This definition includes both redundancies applied to specific disturbances, as in the illustration, and those build into language and used regularly in communication.

The Concept of error-free transmission.

Common-sense analysis suggests that since there is always some type of noise in a communications system there is always some error in the communication which we best hope to reduce to a minimum level.

Shannon's analysis has shown that this is not the case, it's possible if certain conditions are met, to achieve error-free transmissions.

To explain this necessitates the introduction of the idea of protocol, process, device or channel capacity.

Although difficult to compute, it's relatively easy to imagine that any process will have some upper or maximum limit on the amount of information it can transmit, by Shannon's analysis has shown that it is possible to achieve error-free transmissions by the use of proper coding provided the capacity of the channel is not exceeded.

Coding

Essentially coding is transforming the message into a special form for transmission.

In a sense it is a special language which enables is to convey more information in an individual communicative act.

In this way the transmission rate of information can be increased.

The problem is that the original message must be translated into the code, and the process of coding takes time.

Needless to say our objective could have just as well been defined as transmission with 2 per cent or 10 per cent error.

Shannon's concepts enable us to think in terms of precisely defined transmission error with one point being zero error.

Computation

What is computation?

Computation reducible to:

1. Message sending
2. Message receiving
3. Message receiver creation

Message processing, including how to process future messages.

Computer vision

This bits describe a general framework proposed by Marr for studying and understanding visual perception.

In this framework, the process of vision proceeds by constructing a set of representation starting from a description of the input image, and culminating with a description of three-dimensional objects in the surrounding environment.

The final stage in Marr's theory of visual representation was a particular form of three-dimensional (3-D) model of objects in the visual environment, developed with Keith Nishihara.

The main motivation behind this model was the creation of invariant object representation for the purpose of recognition, which will be independent of the particular viewing direction and irrelevant details in the object's shape.

In a working 1973 paper, written with Carl Hewitt and titled Video Ergo Scio they make the following comment: "Our insistence on using 3-D models for the basic representation of objects does not preclude the use of catalogs of appearances of objects from different view points."

Our view is that both types of representations are required computationally, and both are likely to exist within the human visual system.

In 1971, Roger N. Shepard and Jaqueline Metzler made line drawings of simple objects that differed from one another either by a three-dimensional rotation or by a rotation plus a reflection. They asked how long it took to decide whether two depicted ibjects differed by a rotation and a reflection or merely a rotation. They found that the time taken depended on the three-dimensional angle of rotation necesary to bring the two objects into correspondence. One is led thereby to the notion that a mental rotation of sorts is actually being performed, that a mental description of the first shape in a pair is being adjusted incrementally in orientation until it matches the second, such adjustment requiring greater time when greater angles are involved.

What does it mean to see?

But what of explanation? The development of amplifiers allowed Adrian (1928) and his colleagues to record the minute voltage changes that accompanuied the transmission of nerve signals. Their investigation showed that the character of the sensation so produced depended on wich fiber carried the message, not how the fiber was stimulated.

But perhaps the most exciting development was the new view that questions of psychological interest could be illuminated and perhaps even explained by neurophysiological experiments.

Barlow (1972) then goes on to summarize these findings in the following way:

The cumulative effect of all the changes I have tried to outline above has been to make us realise that each single neuron can perform a much more complex and subtle task that had previously been through.

Neurons do not loosely and unreliably remap the luminous intensities of the visual image onto our sensorium, but instead they detect pattern elements, discriminate the depth of objects, ignore irrelevant causes of variation and are arranged in an intriguing hierarchy. Furthermore, there is evidence that they give prominence to what is informationally important, can respond with great reliability, and can have their pattern selectivity permanently modified by early visual experience.

This amounts to a revolution in our outlook. It is now quite inappropriate to regard unit activity as a noisy indication of more basic and reliable processes involved in mental operations: instead, we must regard single neurons as the prime movers of these mechanisms. Thinking is brought about by neurons and we should not use phrases like "unit activity reflects, reveals, or monitors thought processes," because the activity of neurons, quire simply, are thought processes.

This revolution stemmed from physiological work and makes us realize that the activity of each single neuron may play a significant role in perception (p.380)

This aspect of his thinking led Barlow to formulate the first and most important of his five dogmas: A description of that activity of a single nerve cell which is transmitted to and influences other nerve cells and of a nerve cell's response to such infliences from other cells, is a complete enough description for functional understanding of the nervous system. There is nothing else "looking at" or controlling this activity, which must therefore provide a basis for understanding how the brain controls behaviour. Barlow, 1972.

We shall return later on to more carefully examine the validity of this point of view, but for now lets us just enjoy it.

But somewhere underneath, something was going wrong. The initial discoveries of the 1950s and 1960s were not being followed by equally dramatic discoveries in the 1970s.

As one reflected on these sorts of issues in the early 1970s, it gradually became clear that something important was missing that was not present in either of the disciplines of neurophysiology or psychophysics. The key observation is that neurophysiology and psychophysics have as their business to describe the behavior of cells or of subjects but not to explain such behavior.

What are the visual areas of the cerebral cortex actually doing? What are the problems in doing it that need explaining, and at what level of description should such explanations be sought?

Gone are the ad hoc programs of computer vision; gone is the restriction to a special visual miniworld; gone is any explanation in terms of neurons except as a way of implementing a method. And present is a clear understanding of what is to be computed, how it is to be done, the physical assumptions on which the method is based, and some kind of analysis of algorithms that are capable of carrying it out.

The other piece of work was Horn's (1975) analysis of shape from shading, which was the first in what was to become a distinguished series of articles on the formation of images. By carefully analyzing the way in which the illumination, surface geometry, surface reflectance, and view-point conspired to create the measured intensity values in an image. If the surface reflectance and illumination are known, one can solve the surface geometry (see also Horn, 1977). Thus from shading one can derive shape.

The message is plain clear. There must exist an additional level of understanding at which the character of the information-processing tasks carried out during perception are analyzed and understood in way that is independent of the particular mechanisms and structures that implement them in our heads. This was what was missing, the analysis of the problem as an information-processing task. Such analysis does not usurp an understanding at the other levels of neurons or computer programs, but it is necessary complementary to them, since without it there can be no real understanding of the function of all those neurons. The important point is that if the notion of different types of understanding is taking seriously, it allows the study of the information-processing basis of perception to be made rigorous. It becomes possible, by separating explanations into different levels, to make explicit statements about what is being computed and why and to construct theories stating that what is being computed is optimal in some sense or is guaranteed to function correctly. The ad hoc element is removed, and heuristic computer programs are replaced by solid foundations on which a real subject can be built. This realization, the formulation of what was missing, together with a clear idea of how to supply it, formed the basic foundation for a new integrated approach.

Conflict

Organizations that posses the capacity to deal adequately with conflict have been described as follows:

1. They posses the machinery to deal constructively with conflict. They have an structure which facilitates constructive interaction between individuals and work groups.

2. The personnel of the organization is skilled in the process of effective interaction and mutual influence (skills in group ledership and membership roles in group building and maintenance functions).

3. There is a high confidence and trust in one another among members of the organization, loyalty to the work group and to the organization, and high motivation to achieve the organization's objectives.

Confidence, loyalty, and cooperative motivation produce earnest, sincere, and determined efforts to find solutions to conflict. There is greater motivation to find constructive solution that to maintain an irreconcilable conflict. The solutions reached are often highly creative and represent a far better solution than any initially proposed by the conflicting interests.

The essence here is that out of conflict will come a new synthesis superior to what existed before and perhaps superior to any individual point of view existent in conflict.

Conflict, resting in part on different perspectives of what "ought" to be, is one of the avenues for opening new directions for the organization or one of the ways of moving in new directions. This is not only useful but also vital for organizational survival. The question, therefore, as we view conflict is not, "How to eliminate it?" but, "Is it conflict of such a type and within circumstances where it will contribute to rather than detract from organizational interest?"

Whether a conflict is good or bad for an organization, whether a conflict can be made useful for an organization, depends not so much on manipulating the conflict itself as on the underlying conditions of the overall organization. In this sense, conflict can be seen as;

1. a symptom of more basic problems which requires attention

2. an intervening variable in the overall organization to be considered, used, and maintained within certain useful boundaries.

Organizational adaptation frequently proceeds through a new arrangement developing informally, which, after proving its worth and becoming accepted, is formally adopted. The first informal development, however, may be contrary to previously established procedures and in a sense a violation or a subversion of them; or the informal procedures may be an extension of a function for internal political purposes.

Consciousness

Our emphasis is on people in organizations where managers have to make decisions even through their knowledge and concepts may be wrong or inadequate.

As generalizations are made about what takes place in organizations, we shall often be talking about the decision processes that organizational members engage in or the sequence of factors which lead to a particular behavior.

We talk about the possible actions a person may take on recepipt of an order from his superior, which he thinks is improper and unwarranted.

We talk about choossing amount the courses of accepting the order competly, protesting, protesting and raiisng an alternative, or leavng the organization.

It sometimes appers as if there were a basic assumption that people consicosly bring our all these possibilities and rationally weigh the pros and cons of each.

Does the individual at times carry on the same process unconsicusly that on other occasions he perhaps conducts consciously? We hardly know...

We are faced with the fact that people sometimes do things and later say, I never thougth that I would act like that under those circumstances.

In saying this the individual indicates that he saw other opportunities and that, through some process unobservable to him he decided among them and chose on that came from elsewhere that his own conscious thought.

The distiontion between conscious and onconscious thought are by no means easy to determine, and for our purposes, it is not usually necessary to make them.

Considerng the development of the field of Artificial Intelligence at the moment, it seems reasonable to aconduct our analysis at the level at which both machines and humans do make decisions, wihout taling into account whether the choices and decisions processes are consicious or not.

Several references have been made with the intent of this guide to provide conceptial tools for analysis. As ith any other tool models, abstractions and generalizations are useful only when within their limitations.

Control theory

Systems are so extraordinarily complex that it is difficult to deal with them in any detailed fashion.

We are likely to find analyses which discuss the performance of organizational elements in handling the control process but relatively little discussion of how this is accomplished.

Control systems are to a considerable degree influenced by basic human organizational phenomena, principal among them are perception formation, motivation and communications.

The basic elements of the control process are few in number:

- Gathering of data about performance by a sensor;
- Comparison of performance with standard by a discriminator
- When a difference between performance and standard is noted, two courses of action are likely to be taking by a decision maker.

1. Undertake corrective action which will bring performance back into line with standards perhaps by selecting or developing a new process
2. Direct information about this difference to a goal setter for the establishment of new goals or the redefinition of old ones.

When these elements exists, there is control through self-regulation of whatever entity contains them.

The elements, however, may be allocated in a number of ways within the entity.

They may all be performed by one person or each element may be performed by a different person or for that matter, by different departments.

As the work of carrying the control cycle is divided further, coordination of this effort becomes more difficult.

Control as we have been seen it is one type of system, we observe how control has many of the same properties as systems in general; numerous systems interblocked in many ways.

One such way may be seen when there are hierarchies of systems paralleling progression of goals.

There are also systems within systems and loops within the loops. Since control is also a system, it can influence other systems and in turn be influenced by them.

Looking at control as a particular type of system make us appreciate how extraordinarily complex a topic it is, and at the same time gives us an extremely valuable approach to this subject.

Control systems

Control is a word that has a number of meanings.

We are concerned with control in relation to matching performance with necessary or required conditions to obtain a purpose or objective.

The essence here is on reactivity and integration of effort, required accomplishment of an end.

There are a number of different processes which produce control.

Control is concerned not only with events directly related to the accomplishment of major purposes but also with maintaining the organization in a condition in which it can function adequately to achieve these major purposes.

The control process

The study of control has received a great deal of attention by people in number of different fields. This has come about with the realization that control is basic to an extraordinarily wide array of things.

All though the mechanism of control are different in each of these situations, analysis shows the process is the same.

Therefore, people have begun to study control as a universal process, a topic which can be studied in its own right.

There is a data-gathering phase in which a device, in this case generally called a sensor, gathers information about a subject.

Then comes a comparing or examination phase when the desired output is compared with the standard by a unit called a discriminator.

After this comparison is made and, for example a property is noted to be too low corrective action is required; the process is turned on by a unit we will call a decision maker.

Once the process is running, the fist phases are repeated until the discriminator determines that the property has reached or exceeded the upper limit; then another action is required, and the process is shut off.

The basic steps in the control process identified thus far are: gathering data on performance, comparison of data with a standard, and taking corrective action if performance does not match the standard properly.

These phases are carried out by a sensor, discriminator, and decision maker.

Coordination

Having covered the essence of control let us now consider how several loops are connected to provide that synchronization of effort we think of as coordination.

Programmed links

If the process had given instruction to report immediately on completion of the task, this instruction facilitates linking the completed act with the next one. Through an information transfer, we call this a programmed link.

The supervisor node, of course may detect that something is wrong through another control cycle. It can then take corrective action by including or adding into this programmed link or perhaps by attacking on the more difficult problem of human apathetic attitudes and motivation his units could display.

Progression of goals

Organizations have progression of goals which result from a division of work.

A subdivide goal becomes the task of a process contained within a specialized organizational unit.

This nesting of goals is contained as part of the core organizational means-ends chain.

Needless to say, the hierarchy of control loops which are connected with the progression of goals may be handle in number of ways, regardless of how the elements are allocated, the important factor is that all elements must be provided for in some way. Hence, our model supplies an extremely useful tool in analyzing complex control situations by telling us what basic functions bust occur and in what sequence, even though initially we have no idea as to where or how they are executed in the organization.

Goals and feedback

The feedback loop containing information about organizational performance and conditions leads to definition of subunit goals or standards. It's important to show how a situation in one area could lead to modifications in a number of organizational units at higher levels.

This even result in reformulating the basic goals of organizations. Feedback is essential to adequate goal formation.

This leads us to an important point which, when stated without the type of development presented, appears to be a somewhat mystical statement; namely, organizations automatically take actions to bring about their continuity or to perpetuate themselves. Of course there are times when organizations do not change goals and do go out of existence. Many, however, shift to those goals feedback defines as possible; feedback leading to goal redefinition is one of the basic ways by which organizational survival is achieved.

Time discrepancies

Another problem that can exist with control is that the feedback of information on performance takes so long it became impossible to correct performance.

There is another aspect of time which should be mentioned, the time horizon of people in an organization gets progressively shorter as we come down in a hierarchy.

Hence, by taking into account the perceptions of organizations members along with the time during which wortk is being performed on a prohect we can begin to define a time period within wich feedback must occur if adequate corrective action is to be taken.

Differentiable programming

This bits are about a solution to more intuitive computer problems. This solution allow computers to learn from experience and understand the worlds in terms of a hierarchy of concepts, with each concept defined through its relation to simpler concepts. By gathering knowledge from experience, this approach avoids the need for human operators to formally specify all the knowledge that the computer needs.

The hierarchy of concepts enables the computer to learn complicated concepts by building them out of simpler ones. If we draw a graph showing how these concepts are built on top of each other, the graph is deep, with many layers. For this reason, we call this approach differentiable programming.

A person's everyday life requires an immense amount of knowledge about the world. Much of this knowledge is subjective and intuitive, and therefore difficult to articulate in a formal way. Computers need to capture the same knowledge in order to behave in an intelligent way.

One of the key challenges in artificial intelligence is how to get this informal knowledge into a computer.

The difficulties faced by systems relying on hard-coded knowledge suggest that AI systems need the ability to acquire their own knowledge, by extracting patterns from raw data. This capability is known as machine learning. The introduction of machine learning enabled computers to tackle problems involving knowledge of the real world and make decisions that appear subjective.

The performance of current techniques depends heavily on the representation of the data they are given. This dependence on representations is a general phenomenon that appears throughout computer science and even daily life. In computer science, operations such as searching a collection of data can proceed exponentially faster if the collection is structured and indexed intelligently.

Many artificial intelligence tasks can be solved by designing the right set of features to extract for that task, then providing these features to a simple machine learning algorithm. For example, a useful feature for speaker identification from sound is an estimation of the size of the speaker's vocal tract. This feature gives a strong clue as to whether the speaker is a man, woman, or child.

For many tasks, however, it is difficult to know what features should be extracted. For example, suppose that we would like to write a program to detect tanks in Terran worlds.

One solution to this problem is to use machine learning to discover not only the mapping from representation to output but also the representation itself.

This approach is known as representation learning. Learned representations often result in much better performance than can be obtained with hand-designed representations.

A representation learning algorithm can discover a good set of features for a simple task in minutes, or for a complex task in hours to months. Manually designing features for a complex task requires a great deal of human time and effort; it can take decades for an entire community of researchers.

When designing features or algorithms for learning features, our goal is usually to separate the factors of variation that explain the observed data.

Encoding and decoding

Introduction of the idea of code and the process of coding a message makes it apparent that the sender really includes several components.

Since all communication is carried on in some form of language, all communications must have some process of encoding, that is, of translating information into the specific form in which it is going to be transmitted.

Taking an idea and converting it into words in normal conversation is an encoding process, but so is the act of a dude filling in a form using the appropriate numbers and symbols so that the proper material may be drawn from stock.

Needless to say if the information is in code form, there must also be a decoding process in the receiver that extracts the information the code contains.

Selection

In addition to encoding, any sender carries out a process of selection.

There are numerous reasons for this.

One of these is to keep the amount of information going through a system at a reasonable level to avoid overloading the system.

Another is to reduce noise by preventing other than desired messages from entering the system.

Another type of selectivity occurs when information wanted by some members of an organization is kept from entering the communication system or when information important to one individual is introduced into the system by him even though it may not really be what others in the system need.

Selectivity also occurs at the receiving end.

Purposes

Much of communication is intimately tied in with the purposes or needs of the parties involved.

We communicate in order to influence the behavior of others.

Networks

The elements labeled "channels" need some elaboration.

Thus for our mental illustrations have suggested that a channel is nothing more than a simple link, such as a telephone/network wire, between two people/machines.

In organizations, however, channels are frequently not that simple.

As we have noted, a channel may have parties on either end who are both senders and receivers.

There may be a number of connected links in a network so that a message starting at one end of the system has to pass through several people/machines or transmission units in getting to the other end.

Sometimes links carry only certain types of messages, sometimes only in one direction, the conceptual model discussed identified the following elements:

a selector and encoder embodied in the sender, a system of communication links which forms a network called the channel and actually transmits the information, and steps of decoding and selecting information for use which occurs in the receiver.

The movement of information through a system is influenced by two principal factors, its capacity and the noise within it.

If the capacity of the system is not exceeded, the accuracy of the transmission of information is a function of the noise, which, in turn, can be combated by redundancy, which uses up more of the channel capacity, and by coding.

Coding permits more information to be communicated but at a cost of reducing the independence of choice of the persons involved and of bringing about a greater delay in communication because of the necessity of encoding and decoding.

Expectation maximization

(EM) algorithm is an iterative method to find maximum likelihood or maximum a posteriori (MAP) estimates of parameters in statistical models, where the model depends on unobserved latent variables. The EM iteration alternates between performing an expectation (E) step, which creates a function for the expectation of the log-likelihood evaluated using the current estimate for the parameters, and a maximization (M) step, which computes parameters maximizing the expected log-likelihood found on the E step. These parameter-estimates are then used to determine the distribution of the latent variables in the next E step.

Overview

The EM algorithm is used to find (local) maximum likelihood parameters of a statistical model in cases where the equations cannot be solved directly. Typically these models involve latent variables in addition to unknown parameters and known data observations. That is, either missing values exist among the data, or the model can be formulated more simply by assuming the existence of further unobserved data points.

Finding a maximum likelihood solution typically requires taking the derivatives of the likelihood function with respect to all the unknown values, the parameters and the latent variables, and simultaneously solving the resulting equations.

The EM algorithm proceeds from the observation that there is a way to solve these two sets of equations numerically. One can simply pick arbitrary values for one of the two sets of unknowns, use them to estimate the second set, then use these new values to find a better estimate of the first set, and then keep alternating between the two until the resulting values both converge to fixed points. It's not obvious that this will work, but it can be proven that in this context it does, and that the derivative of the likelihood is (arbitrarily close to) zero at that point, which in turn means that the point is either a maximum or a saddle point.

In general, multiple maxima may occur, with no guarantee that the global maximum will be found. Some likelihoods also have singularities in them, i.e., nonsensical maxima.

Factor analysis

A simple linear generative model with Gaussian latent variables.

The observations are assumed to be caused by a linear transformation of lower dimensional latent factors and added Gaussian noise. Without loss of generality the factors are distributed according to a Gaussian with zero mean and unit covariance. The noise is also zero mean and has an arbitrary diagonal covariance matrix.

Factor analysis performs a maximum likelihood estimate of the so-called loading matrix, the transformation of the latent variables to the observed ones, using expectation-maximization (EM).

Overview

Factor analysis is a statistical method used to describe variability among observed, correlated variables in terms of a potentially lower number of unobserved variables called factors. For example, it is possible that variations in six observed variables mainly reflect the variations in two unobserved (underlying) variables.

Factor analysis searches for such joint variations in response to unobserved latent variables. The observed variables are modelled as linear combinations of the potential factors, plus "error" terms. Factor analysis aims to find independent latent variables. The theory behind factor analytic methods is that the information gained about the interdependencies between observed variables can be used later to reduce the set of variables in a dataset.

Proponents of factor analysis believe that it helps to deal with data sets where there are large numbers of observed variables that are thought to reflect a smaller number of underlying/latent variables. It is one of the most commonly used inter-dependency techniques and is used when the relevant set of variables shows a systematic inter-dependence and the objective is to find out the latent factors that create a commonality.

Information collection

The data collection stage is usually done by marketing research professionals. Survey questions ask the respondent to rate a product sample or descriptions of product concepts on a range of attributes. Anywhere from five to twenty attributes are chosen. They could include things like: ease of use, weight, accuracy, durability, colourfulness, price, or size. The attributes chosen will vary depending on the product being studied. The same question is asked about all the products in the study.

Analysis

The analysis will isolate the underlying factors that explain the data using a matrix of associations. Factor analysis is an interdependence technique. The complete set of interdependent relationships is examined. There is no specification of dependent variables, independent variables, or causality. Factor analysis assumes that all the rating data on different attributes can be reduced down to a few important dimensions. This reduction is possible because some attributes may be related to each other. The rating given to any one attribute is partially the result of the influence of other attributes. The statistical algorithm deconstructs the rating (called a raw score) into its various components, and reconstructs the partial scores into underlying factor scores. The degree of correlation between the initial raw score and the final factor score is called a factor loading.

Advantages

Both objective and subjective attributes can be used provided the subjective attributes can be converted into scores.

Factor analysis can identify latent dimensions or constructs that direct analysis may not.
It is easy and inexpensive.

Disadvantages

Usefulness depends on the researchers' ability to collect a sufficient set of product attributes. If important attributes are excluded or neglected, the value of the procedure is reduced.

If sets of observed variables are highly similar to each other and distinct from other items, factor analysis will assign a single factor to them. This may obscure factors that represent more interesting relationships.

Naming factors may require knowledge of theory because seemingly dissimilar attributes can correlate strongly for unknown reasons.

Homeostasis

Inhibitory neurons in the central nervous system play a homeostatic role in the balance of neuronal activity between excitation and inhibition. Inhibitory neurons using acid, make compensating changes in the neuronal networks preventing runaway levels of excitation.

A remarkable property of the nervous system is its ability to adapt itself to surgical alterations of the bodily structure. Bad scientist severed the attachments of the internal and external recti muscles of a monkey's eyeball and re-attached them in crossed position so that a contraction of the external rectus would cause the eyeball to turn not outwards but inwards. When the wound had healed, they was surprised to discover that the two eyeballs still moved together, so that bonicular vision was preserved.

They revered the nerves supplying the flexor and extensor muscles in the arm of the spider monkey, and re-joined them in crossed position. After the nerves had regenerated, the animal's arm movement were at first grossly inco-ordinated, but improved until an essentially normal mode of progression was re-established. The two examples are typical of a great number of experiments, on our monkey friends and will suffice to illustrate here the bits.

Suppose a monkey, to get food from a box, has to pull a lever towards itself; if we sever the flexor and extensor muscles of the arm and re-attach them in crossed position then, so far as the cerebral cortex is concerned, the change is not essentially different from that of dismantling the box and re-assembling it so that the lever has to be pushed instead of pulled. Spinal cord, peripheral nerves, muscles, bones, lever, and box all are 'environment' to the cerebral cortex. It seems reasonable, therefore, to expect that the cerebral cortex will use the same compensatory process whatever the site of reversal.

The nervous system provides many illustrations of such series of events: first the established reaction, then an alteration made in the environment by the experimenter, and finally a reorganization within the nervous system, compensating for the experimental alteration. The homeostat can thus show, in elementary form, this power of self-reorganization.

Inconsistency robustness

Multiple factors make life of self-regulating systems difficult at times one is that they have blind spots where elements working with them are incapable of adequately understanding what is going on.

No natural language is entirely complete or self-sufficient.

The same is true of systems and, in fact, has been since "language" is vital to the transmission of information in a system; but the inconsistency, problem or bug can enter in multiple ways.

To cope with these "blind spots" we have to make use of another vocabulary or system outside the one in which the doubt exists.

By going to another means of communication, such as finding a picture.

The strategy in these solutions is the same.

The incompleteness of the system or language is compensated for by resorting to something outside of the system, by using another language or another system.

Information theory

One sector, semantics, concerns it-self with the meaning of symbols and words.

Another sector, syntax, is concerned with the systematic properties of communication, that is, the relations between the symbols used.

In communications such as the written or spoken words, syntax is concerned with the relationships among letters forming words or the relationships among words in a sentence, grammar.

A third part of communication is concerned with pragmatics and focuses on the relationship between communication and purposeful action.

Each of the approaches to computer communication represents an enormous field of study with many subdivisions.

The central question here is cern in with a communication system. Much of the communications that occur in organizations primarly involve people, and many times the specifics illustrations of the general system pertain to communications among individuals.

Channeling Claude E. Shannon

Shannon originally developed his model of communications while working on problems of telephone communications.

Note that analytical and highly mathematical rather than empirical, these ideas have been the foundation for many concepts grouped under the title of "Information Theory" the important aspects of these concepts are that they have been found application in analyzing not only problems in mechanical systems with links and leavers and in social systems with human beings.

Shannon's model is a general model of communication useful wherever there is a flow of information.

The block labeled Sender, identifies the place, person, or equipment, which produces the message and sends it out.

For the message to move between sender and receiver requires some way of its being conveyed, a Channel.

Channels can take many forms; a simple illustration is telephone wires. Channels may also be radio waves, light waves, sound waves, pieces of paper, etc.

We are concerned hare not only with the various forms of channels but also the ways in which organizations create them or facilitate or impede their creation.

Reinforcement learning

One of the primary goals of the field of artificial intelligence (AI) is to produce fully autonomous agents that interact with their environment to learn optimal behaviors, improving over time through trial and error.

Crafting AI systems that are responsive and can effective learn has been a long-standing challenge, ranging from robots, which can sense and react to the world around them, to purely software-based agents, which can interact with natural language and multimedia.

A principled mathematical framework for experience-driven autonomous learning is reinforcement-learng (RL) combined with the property of deep learning to automatically compact low-dimensional representations (features) of high-dimensional representations data (e.g. images,text and audio).

Through crafting introduce biases into neural network architectures, particularly that of hierarchical representations, machine learning practicioners have made effective progress in adressing the curse of dimensionality.

Differentiable programming enables us to scale decision-making problems that were previously intractable, i.e: settings with high-dimensional state and action spaces.

Unlike the handcrafted rules that have dominated chess-playing systems, AlphaGo was composed of neural networks that were trained using supervised and reinforcement learning, in combination with a traditional heuristic search algorithm.

RL is a general way of approaching optimisation problems by trial and error. A3C combines advantage updates with the actor-critic formulation, and relies on asynchronously updated policy and value function networks trained in parallel over several processing threads.

The use of multiple agents, situated in their own independent environments, not only stabilises improvements in the parameters, but conveys an additional benefit in allowing for more exploration to occur.

Model-based RL

The key idea behind model-based RL is to learn a transition model that allows for simulation of the environment without interacting with the environment directly.

Model-based RL does not assume specific prior knowledge. However, in practice, we can incorporate prior knowledge (e.g., physics based models to speed up learning.) Model learning plays an important role in reducing the amount of required interactions with the (real) environment, which may be limited in practice.

An orthogonal approach to speeding up learning is to exploit parallel computation, in particular, methods for training networks through asynchronous gradient updates have been developed for use on both single machines and distributed systems.

By keeping a canonical set of parameters that are read by and updated in an asynchronous fashion by multiple copies of a single network, computation can be efficiently distributed over both processing cores in a CPU, and across CPUs in a cluster of machines.

Reward-driven behavior

The essence of RL is learning through interaction.

An RL agent interacts with its environment and, upon observing the consequences of its actions, can learn to alter its own behavior in response to rewards received.

This paradigm of trial-and-error learning has it roots in BEHAVIORAL PSYCHOLOGY, and is one of the main foundations of RL.

The other key influence on RL is optimal control, which has lent the mathematical formalism, most notable dynamic programming that underpin the field.

However, the challenge in that the agent needs to learn about the consequences of actions in the environment by trial and error, unlike in optimal control, a model of the state transition dynamics is not available to the agent.

Every interaction with the environment yields information, which the agent uses to update its knowledge, In a control and signal processing context, the observation would be described by a measurement / observation mapping in a state-space-model that depends on the current state mapping the previously applied action.

Stimulus and response

The first objective is to present Donald O. Hebb theory of behavior in some form of ugly cutted digital resume for the consideration of LFE hackers; it seek a common ground with the physics, neurologist, and cognitive scientists, to show them how this bits relates to their problems and at the same time to make it more possible for them to contribute to this guide the first common sense thing to do after consume this bits is get the real thing on paper, so prepare yourself to be amazed by 1949 neural networks.

Ego, Id, and Superego are concepts that help one to see and state important facts of behavior, but they are also dangerously easy to treat as ghostly realities: as agents that want this or disapprove of that, overcoming one another by force or guile, and punishing or being punished.

We can take for granted that any theory of behavior at present must be incomplete.

Modern psychology takes completely for granted that behavior and neural function are perfectly correlated, that one is completely caused by the other. There is no separate soul or life-force stick a finger into the brain now and then and make neural cells do what they would not otherwise.

Our failure to solve a problem so far does not make it unsolvable. One cannot logically be a deterministic in physics and chemistry and biology, and mystic in psychology.

All one can know about another feelings and awareness is an inference from what he say and does from his muscular contractions and glandular secretions. These observable events are determined by electrical and chemical events in nerve cells.

Mind can only be regarded, for scientific purposes, as the activity of the brain, and this should be mystery enough for anyone; besides the appalling number of billions of cells and even more appalling number of possible connections between them.

The problem of understanding behavior is the problem of understanding the total action of the nervous system, and vice versa.

There is much more certainty in the study of the electrical activity of a well-defined tract in the human brain. One can discover the properties of its various parts more or less in isolation; but that part may have properties that are not evident in isolation, and these are to be discovered only by study of the whole intact brain.

The central problem with which we must find a way to deal can be put in two different ways. Psychologically, it is the problem of thought: some sort of process that is not fully controlled by environmental stimulation and yet cooperates closely with that stimulation.

Physiologically, the problem is that of the transmission of excitation from sensory to motor cortex; the transmission may be a very complex process indeed, with a considerable time lag between sensory stimulation and the final motor response.

In mammals even as low as the rat it has turned out to be impossible to describe behavior as an interaction directly between sensory and motor processes. Something like thinking, that is, intervenes. Thought undoubtedly has the connotation of a human degree of complexity in cerebral function and may mean too much to be applied to lower animals. But even in the rat there is evidence that behavior is not completely controlled by immediate sensory events: there are central processes operation as well.

The links are complex and we know practically nothing about what goes on between the arrival of an excitation at a sensory projection area and its later departure from the motor area of the cortex.

In general the bridge can be described as some comparatively simple formula of cortical transmission having all the finer structure of a bowlful of porridge.

Two kinds of formula have been used, leading at two extremes:

1. Switchboard theory, and sensory-motor connections; at one extreme, cells in the sensory system acquire connections with cells in the motor system; the function of the cortex is that of a telephone exchange. Connections rigidly determinate what animal or human being does, and their acquisition constitutes learning.

2. Field theory, at the opposite extreme denies that learning depends on connections at all, and attempts to utilize instead the field conception that physics has found so useful.* The cortex is regarded as made up of so many cells that it can be treated as a statistically homogeneous medium. The sensory control of motor centers depends, on the distribution of the sensory excitation and on ratios of excitation, not on locus or the action of any specific cells.

Despite their differences, however, both theoretical approaches seem to imply a prompt transmission of sensory excitation to the motor side, of only by failing to specify that this is not so. No one, at any rate, has made any serious attempt to elaborate ideas of a central neural mechanism to account for the delay, between stimulation and responses, that seems so characteristic of thought.

But the data of animal behavior have been drawing attention more and more insistently to the need of some better account of central processes. This is what Morgan (1943) has recognized in saying that "mental" variables, repeatedly thrown out because there was no place for them in a stimulus-response psychology, repeatedly find their way back in again in one form or another. What is the neural basis of expectancy, or of attention, or interest?

Any frequently repeated, particular stimulation will lead to the slow development of a "cell-assembly", a diffuse structure comprising cells in the cortex, capable of acting briefly as a closed system, delivering facilitation to other such systems and usually having a specific motor facilitation. A series of such events constitutes a "phase sequence" the thought process. Each assembly action may be aroused by a preceding assembly, by a sensory event, or normally by both. The central facilitation from one of these activities on the next is the prototype of "attention".

It is proposed also that there is an alternate "intrinsic" organization, occurring in sleep and in infancy, which consists of hypersynchrony in the firing of cortical cells. But besides these two forms of cortical organization there may be disorganization.

The theory is evidently a form of connectionism, one of the switchboard variety, the connections server rather to establish autonomous central activities, which then are the basis of further learning. In accordance with modern physiological ideas, the theory also utilizes local field processes and gradients. It does not, further, make any single nerve cell or pathway essential to any habit or perception.

The problem lay in certain puzzling effects of operation on the human brain. The effect of a clearcut removal of cortex outside the speech area is often astonishingly small; at times no effect whatever can be found. It is possible that there is always a loss of intelligence in aphasia, when the "speech area" is seriously damaged.

It would be unreasobale to suppose that most of the cortex has nothing to do with intelligence, and there are fact definite indications that this is not true.

We want to explain certain clinical facts. To really do so, we must find an anatomical and physiological understanding of what is known psychologically as a concept; and we must me able to deal with its relation to perception and to learning.

And with that, we land right in the middle of the generalized problem of explaining mammalian behavior. What is a concept, if it is not a conditioned response? What is perceptual learning? And so on. Before such questions can be answered, psychological theory must have a new base of operations.

It has already been suggested that the essential need is to find out how to handle thought, and related processes, more adequately.

Rejecting complete sensory control

What can be called the assumption of a sensory dominance of behavior. It is the idea that behavior is a series of reactions (instead of actions), each of which is determined by the immediately preceding events in the sensory systems. The idea is not consistent with recognizing the existence of set, attitude, or attention.

In the simplest terms, "attention" refers to a selectivity of response. Man or animal is continuously responding to some events in the environment, and not to others that could be responded to or noticed just as well. When an experimental result makes it necessary to refer to "set" or "attention", the reference means, precisely, that the activity that controls the form, speed, strength, or duration of response is not the immediately preceding excitation of receptor cells alone.

The fact that a response is not so controlled may be hard to explain, theoretically; but it is not mystical, and "attention" is not necessarily anthropomorphic, or animistic or undefinable.

Almost without exception psychologists have recognized the existence of the selective central factor that reinforces now one response, now another. The problem is to carry out its logical conclusion an incomplete line o thought that starts out preoccupied with stimulus or stimulus configuration as the source and control of action, eventually runs into the facts of attention and so on, and then simply agrees that attention is an important fact, without recognizing that this is inconsistent with one's earlier assumptions.

Psychologists have generally recognized the existence of attention or the like; another that they have done so reluctantly and sparingly, and have never recognized the fact in setting up theories, we need to find some way of dealing with the facts consistently; that element is the recognition that responses are determined by something else besides the immediately preceding sensory stimulation. It does deny that sensory stimulation is everything in behavior.

All such terms, then, are a reference to the "central process" which seems relatively independent of afferent stimuli, which we shall call the autonomous central process.

All these things have the same property of an activity that has a selective effect on behavior without being part of the present afferent excitation.

The trouble really seems to have been in finding how to make an essential idea intelligible.

The central process, and central excitation mechanism, are hypothetical entities, but they certainly have no flavor of animism about them. "Attention" and "set" are now seen to fall in the same class: it may well be that their connotations are misleading and that we shall have to look for new terms, but the idea itself is respectable, and such language need no risk starting a witch-hunt.

The problem of attention

There is a further hazard on the course. This is the apparent lack of theoretical rationale for the autonomous central process.

A main function of the neural cell is of course to transmit excitation, and earlier ideas of autonomy and physiology made the central nervous system appear, in principle, a collection of routes, some longer, some shorter, leading without reversal from receptors to actuators, a mass of conductors that lies inactive until a sense organ is excited and then conducts the excitation promptly to some muscle or gland. We know now that this is not so, but the older idea still has a profound effect on psychological thought.

Instead of a joker that occasionally confuse the student of behavior, nonsensory activities appear in every fall of the cards and must make up a large share of the deck. Electrophysiology of the central nervous system indicates that the brain is continuously active, in all its parts, and afferent excitation must be superimposed on an already existent excitation. It is therefore impossible that the consequence of a sensory entity should often be uninfluenced by the pre-existent activity. So there really is rational basis for postulating a central neural factor that modifies the action of a stimulus. The theoretical problem now is to discover the rules by which it operates.

The problem is after all the problem of attention, and seen best in the activity of the whole animal. It is in the highest degree unlikely that it can be solved either from the physiological evidence alone or from the behavioral evidence alone. What we need, evidently, is some synthesis of both kinds of data.

For our purposes, the physiological evidence can be treated under two heads, bearing on:

1. First argument; the existence and properties of continuous cerebral activity,
2. Second argument; the nature of synaptic transmission in the central nervous system.

First argument

Confirmation by Adrian, have shown with practical certainty that central nervous system is continuously active, in all parts, whether exposed to afferent stimulation or not.

There are changes of cell potential without active transmission of impulses, there is a considerable body of evidence to show that neural tissue is persistently active; Elsewhere Adrian (1934, p. 1126) has stated his general conclusions: "There are cell mechanisms in the brain which are set so that a periodic discharge is bound to take place. The moment at which it occurs can be greatly altered by afferent influences, but it cannot be postponed indefinitely."; spontaneity of firing by central neural cells is not philosophic indeterminacy, the "spontaneity" means only that synaptic stimulation is not the sole cause of firing.

Adrian also pointed out, that a cell that is capable of firing spontaneously is also open to synaptic control. A very interesting relationship exist between sensory activity, and coordinated, adaptive behavior or conscious state, sensory processes, instead if supporting synchronous rhythmic firing and large potentials, have the opposite effect. They introduce irregularity and flattening of the electrical record. Large potentials or "hypersynchrony", negate or may negate normal function.

It does seem clear from the facts discussed, from the large potentials observed in sleep, and from the hypnotic effect of minimizing the normal variation of sensory activity, that the sensory input to the brain has a constantly necessary function for adaptive behavior.

Second argument

The nature of synaptic transmission in the central nervous system is also of fundamental importance for the theory of behavior. Transmission is not simply linear but apparently always involves some closed or recurrent circuits; and a single impulse cannot ordinarily cross a synapse-two or more must act simultaneously, and two or more afferent fibers must therefore be active in order to excite a third to which they lead.

In a single system, and with a constant set of connections between neurons in the system, the direction in which an entering excitation will be conducted may be completely dependent on the timing of other excitation. Connections are necessary but may not be decisive in themselves; in a complex system, especially, time factors must always influence the direction of conduction; the idea of connections can again be useful in psychology theory, and the question of "synaptic resistances" is completely reopened modern neuroanatomy and electrophysiology have changed the question completely, and the significance of synaptic connections must be examined all over again.

Our problem, then is to find valid conceptions of neural action, conceptions that can be applied to large-scale cortical organizations.

Perceptual structural memory trace

The assumption we must accept is that the memory trace, the basis of learning, is in some way structural and static; a learned discrimination is not based on the excitation of any particular neural cells. It is supposed to be determined solely be the pattern, or shape, of the sensory excitation; the pattern and not the locus of stimulation is the important thing, has developed a theory of electrical fields in the brain which control cerebral action.

The mnemonic trace, the neural change that is induced by experience and constitute "memory", is not a change of structure. The idea that the trace is structural but diffuse, involving, that is, a large number of cells widely spaced in the cortex, physiologically but not anatomically unified.

Thus the only barrier to assuming that a structural change in specific neural cells is the basic of memory lies in the generalization of the perception of patterns. Man sees a square as a square, whatever its size, and in almost any setting. These are concrete, undisputed facts of behavior. They have been interpreted as meaning that perception is independent of the locus of excitation; and this interpretation has been accepted as inescapable. The result is an awkward dilemma for theory, since, as we have seen, it is hard to reconcile an unlocalized afferent process with a structural localized mnemonic trace.

The attack mode

How are we to provide for perceptual generalization and the stability of memory, in terms of what neuron does and what happens at the synapse? We must suppose that the mnemonic trace is a structural change; the difficulty, in suooising it, is a conflict with the idea that only the pattern, and not the locus of sensory stimulation, is important in perception.

That paragraph puts the theoretical approach of this monograph. We propose to go over the evidence again on perception and show that it is not what it seems. We do not know that pattern is everything, locus nothing. Perception does depend on exciting specific parts of the receptor surface; mnemonic trace and perceptual generalizations need no longer to be at odds with one another; a physiological meaning of attention (or set, or expectancy) shows up.

The reader will observe that the discussion deals almost entirely with visual perception. This is not because vision has any unique significance, but because it is in visual perception, with few exceptions, that the problem of patterning and form has been studied experimentally.

Learning in Perception

The immediate objective is to show that "simple" perceptions are in fact complex; their apparent simplicity is only the end result of a long learning process.

One must decide whether perception is to depend:

1. on the excitation of specific cells,
2. on a pattern of excitation whose locus is unimportant.

Current (1949) opinion seems tacitly to have accepted the Gestalt argument that the only tenable assumption is the second of these possibilities.

The theory presented here is diametrically opposed to this aspect of Gestalt theory, and is based on assumption 1, that a particular perception depends on the excitation of particular cells at some point in the central nervous system.

The perception of identity depends on a series of excitations, the perception is additive, a serial reconstruction though very rapid and "unconscious" for the normal adult. Simple figures do not always act as wholes, innately. But it is undoubtedly true that they sometimes do so in one respect, in the figure-ground relationship: so this property of a perceived figure is to be distinguished from others, in which summation and learning are important.

Accordingly, the following conceptions are distinguished:

1. a primitive, sensory determined unity of a figure is defined here as referring to that unity and segregation from the background which seems to be a direct product of the pattern of sensory excitation and the inherited characteristics of the nervous system on which it acts,
2. a nonsensory unit, affected by experience defined as one in which the boundaries of the figure are not fixed by gradients of luminosity in the visual field. Affected by experience and other nonsensory factors, and is not inevitable in any perception. In general terms, the nonsensory figure occurs in perception whenever the subject responds selectively to a limited part of a homogeneous area in the visual field.
3. the identity, also affected by experience, of a perceived figure.

In contrasting the primitive and the nonsensory figure, however, one need nt imply that a perceived figure must be either of one or the other kind. They are rather two extremes, and in most perceptions both sensory and nonsensory factors affect figure-ground organization.

Even commoner in everyday perception is the perceived entity in which both sensory and nonsensory factors cooperate.

Success in discrimination and generalization evidently depends on one's finding a differentiating characteristic between two figures, or one that is common to a pattern already known and the new one which is presented in the testing situation. No one today would argue that perceptual organization is wholly acquired; there is some innate organization. But this of course does not show that the organization is entirely innate.

There is always a possibility that perception has a partly innate, partly learned organization; and that besides the figure that has a "primitive unity" there are "nonsensory figures" in which experience has an important role.

It is notorious that attention wanders, and this is another way of saying that in perception any figure is unstable; one looks at this part of the configuration and that, and notices its corners or smooth contours, in the intervals between seeing the figure as a whole.

Identity in perception

Identity is defined here as referring to the properties of association inherent in a perception. The reference has two aspects: first, a figure is perceived as having identity when it is seen immediately as similar to some figures and dissimilar to others that is, when it falls at once into certain categories and not into others.

This similarity can be summed up as spontaneous association, since it may occur on the first exposure to the stimulus object. Secondly, the object that is perceived as having identity is capable of being associated with other objects or with some action, whereas the one that does not have identity is recalled with great difficulty or not at all, and is not all, and is not recognized or named easily.

Identity of course is a matter of degree and depends on a considerable amount of experience; it is not innately given, an approach to this conception, using the term "identifiability" and has proposed that identifiability promotes the formation of associations.

If we go a little further, it appears that the proposition is circular. Identifiability is not merely a perceptible difference of one figure from another when the two are side by side, but implies a rememberable difference, identifiability is clearly related with previous experiences, recognizability; and recognition is one form of association and associability affects the ocurrence of associations.

The real point at which we are driving seems to be that there are genuine differences of associability in different patterns. Also, more is involved in these differences than the number of trials necessary to establish recognition; there are also the spontaneous associations referred to in speaking of similarity.

An irregular mass of color or a pattern of intersecting lines drawn at random has some coherence and unity, but one such figure is not readily recognized and distinguished from others when it is seen a second time, and generalization (or similarity) is not selective among a number of such stimuli.

We distinguish between the "so-called generalization" which means only a failure to observe differences and the generalization which involves perception of both similarities and differences. The amorphous figure, lacking in identity, is generalized in the first sense only.

A further illustration of these points is found in the development of identity in the perception of capuchin monkey faces by one who has seen no capuchin monkeys before.

Two animals seen side by side are obviously different in details, but the inexperienced observer is not able easily to remember one selectively. Also, all capuchin monkeys at this stage look alike; the "so-called generalization" occurs. With experience the perception of identity increases. Similarity is still perceived between animals, and cofusion between some animals is still possible; but there is a marked change in the perception.

Thus identity is a matter of degree: readiness of recognition, and the extent to which generalization is selective.

This bits has been meant to establish the conception of "identity" as an important property of perception which should be kept carefully distinct from the "unity" of the perceived figure (as well as from its "meaning"). Unity may be innately determined, an immediate property of sensory dynamics, whereas identity is dependent on a prolonged experience.

Learning to perceive

Ordinary visual perception in higher mammals presupposes a long learning period. The course of perceptual learning in man is gradual, proceeding from a dominance of color, through a period of separate attention to each part of a figure, to a gradually arrived at identification of the whole as a whole: an apparently simultaneous instead of a serial apprehension.

The shortest time in which a subject approximated to normal perception, even when learning was confined to a small number of objects, seems to have been about a month.

It is possible then than the normal human infant goes through the same process and that we are able to see a square as such in a single glance only as the result of complex learning.

Gellerman (1933) reports that chimpanzees and two-year-old children recognized a triangle that had been rotated through 120 from the training position, but (in the one protocol that is given) responded selectively only after a head rotation; and persistent head rotation continued in the later discriminations.

When a simple figure such as square, circle, or triangle, subtenting a retinal angle of from 2 to 10 is fixated at one point it tends in a second or so to become almost amorphous except near the point of fixation.

The factors involved are evidently complicated; it will be found, for example, that with a large fogure merely imagining eye-movements (of following the contours) will restore definition of the figure. Also, these "imaginary" eyemovements, or subliminal activations of the motor system, occur more frequently and are less easy to control in looking at a smaller than at a larger figure, and it is hard to be sure that the size of the figure is unimportant. But this at least seems definite, that a stable, clear, and effective perception of circle or square is more possible with eyemovement than without.

The point is not that eyemovements are essential to perception by a sophisticated observer (nor, in the following paragraph, that they are completely necessary for an image); but that the perception is definitely clearer, more effective, with them than without.

This is really an evident fact. It is to be interpreted in the light of all evidence, showing that the perception of square or circle is slowly learned and depends originally on multiple visual fixations.

Evidence found on a one-sided loss of vision by monkeys on extirpation of the opposite frontal eyefield, a cortical motor area for head-and-eye movement. The most significant and striking observation was startle by the monkey when an object was passed from the blind side into the seeing side, at the moment of passing the midline.

Now the question is what the motor cortex can have to do with visual perception unless perception intimately involves a motor activity, liminal or subliminal.

Perception of even a simple object involves a "phase sequence." This is a chain of central cortical events with motor links. Although the motor activations may be subliminal and do not always produce overt response, their role is essential in any perception.

Animal experiments and the human clinical data alike indicate that the perception of simple diagrams as distinctive wholes is not immediately given but slowly acquired through learning.

The process of "successive part reinforcement," as an aid to perception, exists at the same time as an essential unity of the whole; and theory must provide for the additive process, with its motor elements, as well as for the primitive unity. The thesis is that eyemovements in perception are not adventitious. They contribute, constantly and essentially, to perceptual integration, even though they are not the whole origin of it.

System identification

The art and science of building mathematical models of dynamic systems from observed input-output data. It can be seen as the interface between the real world of applications and the mathematical world of control theory and model abstractions.

The field of system identification uses statistical methods to build mathematical models of dynamical systems from measured data this also includes optimal design of experiments for efficiency generating information data for training such models as well as model reduction

A dynamical mathematical model in this context is a mathematical description of the dynamic behavior of a system of process in either the time or frequency domain

Sometimes pure feed-forward control without feedback is called "ballistic" because once a control signal has been send it cannot further adjusted any corrective adjustment must be by way of a new control signal.

In contrast "cruise control" adjust the output in response to the load that it encounters, by a feedback mechanism.

Grey box model

In mathematics, statistics, and computational modeling a gray box model combines a partial theoretical structure with data to complete the model,

The theoretical structure may vary from information on the smoothness of results, to models that need only parameters values from data or existing literature.

Feedback

Which adjusts the output to take account of how it affects the load, and how the load itself may vary unpredictably; the load is considered to belong to the external environment of the system.

Feed-forward

The element of control that passes a signal from a source in its external environment, often a command from a external operator, to a load elsewhere in its external environment.

A system which has only feed-forward behavior responds to its signal in a pee-defined way without responding to how the load reacts; its is in contract with a system that also has feedback.

The fall of lambda

Logic programming is the proposal to implement systems using mathematical logic.

Perhaps the first published proposal to use mathematical logic for programming was John McCarthy's Advice Taker paper.

Planner was the first language to feature "procedural plans" that were called by "pattern-directed invocation" using "goals" and "assertions". A subset called Micro Planner was implemented by Gerry Sussman, Eugene Chariak and Terry Winograd and was used in Winograd's natural language understanding program SHRDLU, and some other projects.

This generated a great deal of excitement in the field of AI. It also generated controversy because it proposed an alternative to the logic approach one of the mainstay paradigms for AI.

The upshot is that the procedural approach has a different mathematical semantics based on the denotation semantics of the Actor model from the semantics of mathematical logic.

There were some surprising results from this research including that mathematical logic is incapable of implementing general concurrent computation even though it can implement sequential computation and some kinds of parallel computation including the lambda calculus.

Classical logic blows up in the face of inconsistent information that is becoming more ubiquitous with the growth of the internet.

We have pass the midst of a huge paradigm shift and live now in a massive concurrent world full of new buzz words like IoT, cloud and edge computing, web and micro services and multi-core computer architectures living mostly in every computer and consumer device.

This change enables a new generation of systems incorporating ideas from mathematical logic in their implementation, resulting on some reincarnation of logic programming. But something is often transformed when reincarnated!

Actor model

Actors are the universal primitive of concurrent digital computation. In response to a message that it receives, an actor can make local decisions, create more Actors, send more messages, and designate how to respond to the next message received.

Unbounded nondeterminism is the property that the amount of delay in servicing a request can become unbounded as a result of arbitration of contention for shared resources while still guaranteeing that the request will eventually be serviced.

Arguments for unbounded nondeterminism include the following:

There is no bound that can be placed on how long it takes a computational circuit called an Arbiter to settle.

- Arbiters are used in computers to deal with the circumstance that computer clocks operate asychoronously with input from outside, "e.g, keyboard input, disk access, network input, etc..."
- So it could take an unbounded time for a message to sent to a computer to be received and in the meantime the computer could traverse an unbounded number of states.

A limitation of logic programming

In his 1988 paper on early history of Prolog, Bob Kowalski published the thesis that "computation is controlled deduction" which he attributed to Pat Hayes.

Contrary to Kowalski and Hayes, Hewitt's thesis was that logical deduction was incapable of carrying out concurrent computation in open systems because of indeterminacy in the arrival order of messages.

Indeterminacy in concurrent computation

Hewitt and Agha [1991] argued that: The Actor model makes use of arbitration for determining which message is next in the arrival ordering of an Actor that is sent multiple messages concurrently.

For example Arbiters can be used in the implementation of the arrival ordering of an Actor which is subject to physical indeterminacy in the arrival order.

In concrete terms for Actor systems typically we cannot observe the details by which the arrival order of messages for an Actor is determined. Attempting to do so affects the results and can even push the indeterminacy elsewhere.

Instead of observing the internals of arbitration processes of Actor computations, we await outcomes.

Physical indeterminacy in arbiters produces indeterminacy in Actors. The reason that we await outcomes is that we have no alternative because of indeterminacy.

According to Chris Fuchs [2004], quantum physics is a theory whose terms refer predominately to our interface with the world. It is a theory not about observables, not beables, but about 'dingables' we tap a bell with our gentle touch and listen for its beautiful ring.

It is important to distinguish between indeterminacy in which factors outside the control of an information system are making decision and *choice* in which the information system has some control.

It is not sufficient to say that indeterminacy in Actor systems is due to unknown/unmodeled properties of the network infrastructure. The whole point of the appeal to quantum indeterminacy is to show that aspects of Actor systems can be unknowable and the participants can be entangled.

The concept that quantum mechanics forces us to give up is: the description of a system independent from the observer providing such a description; that is the concept of the absolute state of a system. I.e, there is no observer independent data at all.

According to Zurek [1982], "Properties of quantum systems have no absolute meaning. Rather they must always characterized with respect to other physical systems."

Does this mean that there is no relation whatsoever between views of different observers? Certainly not. According to Rovelli [1996] "It is possible to compare different views, but the process of comparison is always a physical interaction (and all physical interactions are quantum mechanical in nature)".

The labeling trouble

The basic trouble with the labeling approach of scene analysis is that it is too limiting and stultifying a paradigm for vision, in much the same way that resolution is for deduction.

The fundamental principle of resolution that **(not A)** and **(A or B)** together imply B, is occasionally useful.

But attempting to make a uniform resolution proof procedure, to mechanize deduction in a way that cannot be very sensitive to hints, hunches, and a wide variety of higher level knowledge about the particular domain in question is a cul-de-sac.

Similarly, the line and vertex labels are local predicates that are occasionally useful, and are of some mathematical interest in their own right: but the problem of creating a uniform procedure to label arbitrary line drawings is not a central one for vision.

The proper endeavor of vision research is to decide what knowledge should be used to help a vision system to see, and discover methods that make it possible to use such knowledge.

How can one pursue this goal more effectively? There are two kinds of answer.

Abandon the restrictive format of line drawings, so that programs can use information about visual features that are not coded in this form. To this end, a whole field called picture processing has arisen, that studies simple low-level algorithms for picking out regions from visual scenes.

People who study picture processing are however greatly hampered by not knowing what they are processing the picture for: evaluation for the success of a technique is therefore a subject matter, and is often avoided altogether.

The second kind of answer, lying at the opposite end of the spectrum, consists of a more abstract approach to how to represent knowledge in intelligent systems, (Fillmore 1969, Abelson 1973, and Minsky 1973.)

Roughly, the force of these ideas is that knowledge should be organised into quite large chunks, called frames.

We believe that these ideas are exciting because they suggest ways in which a system might be given access to much more knowledge that has been possible; but general theories often skate over the thorny issue of low-leel vision, which are probably mainly responsible for holding up progress in the area.

Our proposal is to combine both approaches! because this cannot be done in the abstract, we intent to take a particular visual domain, and set out carefully an explicit catalogue of the knowledge that ought to be used by a program trying to see things in it.

We have chosen a world in which most of the important issues of three-dimensional vision are raised, yet which is sufficiently simply that implementing an experimental system is not out of the question.

The world is a Fiscnertechnik construction kit. This is a well-designed set of parts of various shapes and sizes, made of metal or plastic, from which small mechanical assemblies may be constructed: to be able to operate successfully in this world requires a considerable knowledge of spacial relations, and knowledge of shape and of function.

This resume describes briefly how we propose to do this, and sketches the catalogue of knowledge that we hope eventually to obtain, and prove useful. We subdivide the catalogue into MINI-WORLDS, according to the criterion that relations between items in a MINI-WORLD are much denser than between items in different ones.

Because we have a partly procedural model in mind, a MINI-WORLD should be thought of as an active collection of knowledge specialists.

The list of MINI-WORLDS that we offer here, and the partition of knowledge that it represents, is a tentative one.

Outlines

Our inquiry is basically epistemological, explores the interesting territory between knowledge that one would like to use, and knowledge that is actually available to be used.

People do not take seriously the possibility of extracting blobs, bars, and spots in all kinds of positions and orientations when a clever serial region finder or line extractor will provide much more valuable results in the same time.

The only circumstances in which one even consider doing something like this is if one had several orders of magnitude more computing power available: and if one had it, it is clear that ones basic approach to the problem of vision might be different.

Yet we animals probably do have a great deal of special purpose computing power available for early visual processing.

Perhaps the most powerful idea that it becomes feasible to contemplate is that of running an analysis simultaneously at several different image resolutions.

One of our objectives is to study how to make use of this kind of knowledge about a visual scene, with the ultimate intention of formulating a prescription for a piece of hardware capable of providing it. (Note this was 1973!)

Our second principal interest arises because the world is basically 3-dimensional, and so if the system is to be able to handle a large amount of knowledge about the world, a decision has to be made rather early about whether to represent such knowledge in a 2-D knowledge solely about appearance or in a 3-D language.

A major theme runing thorugh our approach, and one that we shall try to justify, is that the representation of visual objects should be translated into 3-D language as soon as possible.

Thus we distinguish between that we call a VIEW of an object, and an underlying 3D model of that object.

The VIEW is a perpheral mini-world in which low level visual routines can leave assertions about what they see outside.

The VIEW knows about the possible different directions away from the viewer, which directions are near which other directions, and it has a crude knowledge about distance away from the viewer. (It seems familiar to the camera in a 3-D engine)

Closely associated with this world are other mini-worlds that can describe two-dimensional shape, movement, colour, and disparity between e.g the images on two cameras leaving their information bound to the names of directions in the view.

The view is thus like a canvas on which these features are painted to be studied and interrogated by more central routines.

The final ingredient of the view is the CUE. One form of CLUE is a particular combination of predicates, which can be bound to the view and which suggests the presence of a particular 3-D structure.

Clues

Such CLUES are like masks that act as triggers to specific central 3-D representations, and cause them to ask particular questions to try to verify that they represent is actually visible.

3-D models are arranged into a number of mini-worlds: the first concern descriptions of primitive 3-D shapes, and later ones, the elaboration of these into representations of the objects with the system has to deal.

Each 3-D model has its set of triggers, e.g the CUES from the VIEW mini-worlds, and a body of code that it will try to execute if it is triggers, ranging from low resolution visual CUES, through high resolution clues that detect a particular detail, to clues arrived at from a guess at the whole object. Notice that triggers are simply special ways of using an important kind of knowledge, akin to the role that features play in a systematic grammar for natural language (Halliday 1968).

3D models are designed to suicide as early as possible, if they are inappropriate: and should be regarded as specific suggestions about how to see the information that caused their activation.

Knowledge about the failure of a 3-D model can act as a trigger to other 3D models, yet another kind of information that the system must be able to use. It is a basic philosophy of the system that the 3-D representations of the world are what the system "remembers", and what it tries to maintain consistent with the information bound to the VIEW.

Our insistence of using 3D models for the basic representation of objects does not preclude the use of catalogues of appearances of objects from different viewpoints.

Indeed we regards knowledge about appearances as indispensable kinds of CLUE.

Plans

It is helpful to introduce a tentative basic unit of organization of knowledge, called a PLAN! a 3-D model is a particular type of PLAN.

A plan consists of code that serves the following three purposes:

1. A trigger, that defines the circumstances in which the plan is run. The trigger defines the CLUES for the plan, and a given CLUE may depend on more than one circumstance. Furthermore, clues may be armed by particular circumstances, so that information that in one context fails to elicit a particular plan, in more suggestive circumstances will succeed.

2. A body of code that runs when the plan is triggered. The body can apply further tests to see if the plan is really applicable and otherwise record its impressions of the situation in which it is being executed. It can contain other kinds of information, like what to do if the plan fails, and how to acquire more information about something the plan ran successfully on.

PLANS are derived from a mixture of sources: from the "state vectors" of McCarthy (1964), from PLANNER-69, from an unpublished character recognition program that uses PLANS to represent the characters (Blomfied, Marr & Mollison 1972) and from ideas that come under the general heading of frame theory (Minsky 1973).

Finally, at the risk of offending purists, we would like to mention that scattered over clinical and neurophysiological literature are hints that the mechanisms of masks, clues, and underlying 3-D representations that we organized into small theory of recognition, may have fairly closely corresponding analogs in primate and in Human visual systems.

When we know in more detail the kinds of assertions that are useful for 3-D representations, it may be possible to formulate a succinct and concrete hypothesis about the kind of single unit response that one would expect from cells in the relevant occipito-parietal regions.

Hypothesis of this kind are extremely difficult, but not quite impossible, to formulate: they are however comparatively easy to test.

Uncommon nonsense

In Ludwig Wittgenstein's writings, the word "nonsense" carries a special technical meaning which differs significantly from the normal use of the word. In this sense, "nonsense" does not refer to meaningless gibberish, but rather to the lack of sense in the context of sense and reference. In this context, logical tautologies, and purely mathematical propositions may be regarded as "nonsense". For example, "1+1=2" is a nonsensical proposition.

Wittgenstein wrote in Tractatus Logico Philosophicus that some of the propositions contained in his own book should be regarded as nonsense. Used in this way, "nonsense" does not necessarily carry negative connotations.

Undecidable decisions

One of the factors that make the life of self-regulating systems difficult at times is that they have blind spots where elements working with them are incapable of adequately understanding what is going on.

No natural language is entirely complete or self-sufficient.

The same is true of systems and, in fact, has been since "language" is vital to the transmission of information in a system; but the inconsistency, problem, bugs can enter systems in multiple ways.

To cope with these "blind spots" we have to make use of another vocabulary or system outside the one in which the doubt exists.

By going to another means of communication, such as finding a picture.

The strategy in these solutions is the same.

The incompleteness of the system or language is compensated for by resorting to something outside of the system, by using another language or another system.