THE CHOICE OF A RESEARCH DIRECTION
(The Principles of CENTAUR)

V.V. Vikhrev[1]

Moscow, Russia

The algōrithm of the chess program CENTAUR arose in connection with attempts to find the best strategy of distribution of resources among competing directions of research. This problem is particulary urgent, given the growing expenditure on research and can be formulated as follows.

Let several ways be suggested for securing an advantage and let it be required to find the best of them. With unlimited resources for research, the problem does not arise. But with limited resources, the directions of research become competitive, giving rise to the problem of the optimal distribution of resources, with the advantage being maximized at a maximum confidence level.

At first sight, the problem is insolvable since it requires prior knowledge of research still to be performed. Nevertheless, it is possible to distribute resources to research gradually, as information about their outcome accumulates gradually. In this way, the problem becomes sensibly solvable again.

A solution, then, necessitates defining the order in which research is to be carried out and defining a distribution of resources such that, taking account of the results already in hand, it would stimulate research likely to be most effective.

An equal distribution of resources among competing research directions is one example of the simplest strategy applicable; being so simple, it is often applied. It has the obvious shortcoming of a very shallow depth in its effects. As a slightly more realistic way, one might specialize to only a few selected paths of achieving the effect desired and to restrict one's investigation to those only. But, doing so, one runs considerable risk of overlooking ways to achieve the goal desired, but not apparent in time. In order to combine the objectives (not losing sight of the main directions preferred nor running an undue risk of overlooking some late discoveries), we introduce the following procedure for evaluating directions of research. For each direction, three numbers must be estimated: **O** - an optimistic value of the direction, **R** - a realistic value and **P** - a pessimistic value.

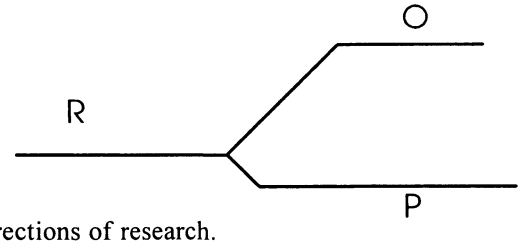

Figure 1: Three directions of research.

The difference between the optimistic and the pessimistic value is a measure of the indefiniteness of the value of that direction of research. Figure 1 illustrates, by exhibiting **O - P**, the degree of vagueness, small when directions have been well-investigated and large for some others.

As research progresses, this uncertainty should contract and **O**, **P** and **R** should come closer together.

It is convenient to examine the competing directions pairwise:

1. The optimistic value of direction **A** is lower than the pessimistic value of direction **B** (see Figure 2a). It is clear that in this case direction **A** should not be investigated as, at best, it can give less than direction **B**, however unfavourable the conditions.

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[1] Russian Research Center "Kurchatov Institute", Institute of Nuclear Fusion, Moscow 123182, Russia.

2 The whole uncertainty of the values of direction **A** lies in the uncertainty of the values of trend **B** (see Figure 2b) In this case, the research of direction **A** should be suspended in favour of investigating direction **B** which has a greater uncertainty in its value It is most important to research direction **B** as there is a probability that its pessimistic value will rise over the optimistic value of direction **A** So the position of uncertainties will come to case 1 and there will be no need of researching direction **A**

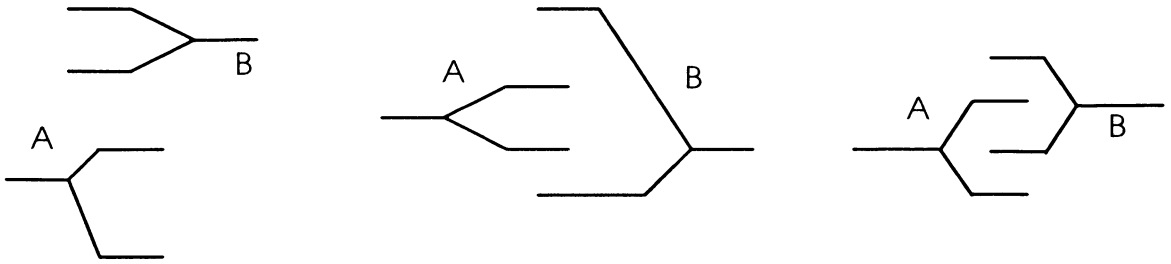

Figure 2: Comparison of competing research directions

3 The uncertainties of two values of directions overlap each other partially (see Figure 2c) In this case, direction **B** is preferred to be researched as there is a probability that during its research the value **P** of direction **B** will rise over the value **O** of direction **A**, trend **A** will not have to be investigated

Three conclusions

These three cases make evident that the direction with the maximum optimistic value is preferred to be pursued This is the most important conclusion of the reasoning presented

At first sight, the conclusion is strange, since it does not allow for wild directions, i e , those which have a high but unknown and thoroughly strange optimistic value It seems there is no gain in spending research on wild directions

Nevertheless, experience proved that research of wild directions does not cause much expense, as their optimistic value quickly falls during cursory researches into them As a result, a high optimistic value is held only by really important directions, demanding detailed research

Every search of the best way is limited in time Therefore, should the pessimistic value of one direction overtop all of the optimistic values of the competing directions, the search may be terminated, choosing the direction having achieved the highest value

The second important conclusion of the reasoning reported is that, as the uncertainty becomes smaller, the policy is no longer to investigate this direction of research, however much it was favoured beforehand This is due to the fact that, however small the uncertainty, this very circumstance is bound to increase the optimistic values for competing research directions

If the condition of ceasing the researches is not fulfilled (within the time set for selecting an optimum) the optimum, by default, is then defined as the extremal realistic or pessimistic value Hence, we have a third conclusion the ultimate choice of a direction of research is fully determined by its realistic or pessimistic value The optimistic value of the direction differentiates between those that should be intensively investigated and those that will and must be designated as the ultimate choices These sets do not normally coincide and their determination relies on completely different algorithms