ASPECTS OF OPTIMAL SLIDESMANNSHIP

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ABSTRACT

This paper deals with some important aspects of Slidesmanship. It is well known that Slidesmanship is one of the many facets of Conferencemanship, an area of scientific endeavour which can yield great rewards to its skilled practitioners, but also embodies possibilities of disastrous mistakes. Our purpose is to employ optimal control theory to provide some easily applicable guidelines for the Slidesman who must decide on such crucial questions as, for instance, how many Slides to present, the proper timing of these slides, and at what time to terminate the presentation.

The Slidesman's objective is, of course, to convey, effortlessly, to the members of the audience, his transcendent superiority over them.

D.H. Wilkinson

1. INTRODUCTION

It is well-known that oral presentations of research results is a necessary and useful part of scientific endeavour. Why then is it sometimes done ineffectively or downright poorly? The answers are fairly obvious. In Sindermann (1982) a few of them are mentioned.

- The scientist may not have much training in public speaking.
- The scientist has misjudged his or her audience.
- The scientist is presenting the paper only to ensure that his or her travel will be funded.
- The scientist has not taken the required time to prepare a good oral presentation.
- The scientist has merely read a prepared text (a deadly business).
In short, for some reason or another, the scientist did not bother to prepare for the presentation.

Every Conferenceman of the 1980s knows that the backbone of any serious conference presentation is a Set of Slides. Good - even excellent - slides are rarely seen, and are warmly welcomed by the audience. Production of such slides is, however, not easy. Because of space limitations we shall refrain from going into this important question here; in Reference 1 some guidelines for the Slidesmaker are given. But the number of slides presented, and their timing, are also essential control variables of the Slidesman.

This paper provides some easily applicable guidelines for an unexperienced Slides(wo)man, based on careful modeling and analysis. In particular, we focus on the optimal determination of the number of slides, their timing, and the duration of the talk.

In Section 2, we discuss the problem of a Slidesman and develop our basic optimal control model. In Sections 3.1 and 3.2 this model is analyzed. Section 3.3 considers the models of Sections 3.1 and 3.2, respectively, under an assumption of a forgetful audience. Our recommendations are given in Section 4 which also delineates some avenues for future research.

2. THE SLIDESMAN'S PROBLEM

Consider the following scenario. A Slidesman is in the process of preparing a talk to be given at a certain conference. Let

N : total number of slides prepared; N ≥ 0

y = y(t): cumulative number of slides presented by time t,

where 0 ≤ t ≤ T. For reasons of analytical elegance we suppose that N and y, respectively, may be varied continuously. Furthermore, define

x : remaining number of slides by time t

and notice the identity

x = N - y  \quad (1)

Obviously, it must also be true that

x(0) = N and y(0) = 0

It should be kept in mind that x and y, respectively, are time functions whereas the number of slides prepared, N, is fixed and cannot be changed during the presentation. Hence, we do not allow the Slidesman an option of pre-
paring additional slides during the talk.

In an optimal control framework, we take x and y as state variables. Differentiation in (1) yields

\dot{x} = -\dot{y}

and defining \dot{y} = u = u(t) yields the fundamental state equation

\dot{x} = u \quad x(0) = N \quad (2)

In (2), the variable u is a control variable of the Slidesman and we may interpret u as the presentation rate at time t.

Notice that the instant T determines the duration of the presentation. We assume that T is free which means that T is to be determined optimally by the Slidesman. Let us consider some alternative ways to constrain T.

(a) One option would be to introduce in the objective functional of the Slidesman a penalty term, say, c(T - T)^2, where T is the 'official' length of a presentation. For example, T = 30 minutes. Hereby both too short and too long presentations are penalized. (Other penalty functions could be chosen, for instance, such that the Slidesman is not penalized when T ≤ T, or even is rewarded in such a case. The latter alternative reflects the fact that audiences (but not necessarily chairmen) tend to prefer short talks).

(b) If the chairman demands strict adherence to the time limit, T, then we impose the constraint

0 ≤ T ≤ T \quad (3)

Both options will be utilized in what is to follow.

As to the control variable, u, is is sensible to impose the constraint

0 ≤ u ≤ u_m \quad \text{for all } t \quad (4)

The upper bound, u_m, is constant and reflects restraints such as the talking speed and general physical condition of the Slidesman. The upper bound on the presentation rate is, to a certain extent, artificial; it can be arbitrarily large (but not infinite) and is introduced to avoid impulsive controls. (Such controls do not make sense in the problem at hand. Using impulsive control would mean, for instance, that all slides were presented simultaneously at the very start of the talk).
For the state variable \( x \) we impose the terminal constraint
\[
x(T) \geq 0 \quad \Rightarrow \quad y(T) \leq N.
\] (5)

Hence, at \( t = T \), the Slidesman has either some unpresented slides left, or exactly all slides were shown. In a case where \( x(T) \) is positive we have a situation where the Slidesman did not use all the slides that were prepared. Let
\[
k : \text{the average effort used to prepare one slide}
\]
such that \( k = \text{constant} > 0 \). The term \( kx(T) \) represents the loss of effort by preparing slides that were not presented. We assume that this is a once and for all loss. Thus, unused slides cannot be recycled at another conference which, admittedly, may be contrary to the experience of some Conferenceman.

Based on empirical evidence we assume that the number of slides is an essential variable characterizing a presentation and suppose that the Slidesman as well as the audience enjoy some utility from the cumulative number of slides presented. To be more specific, define the following instantaneous utility function
\[
U(y) = ay - by^2
\]
where \( a, b \) are positive constants. (Recall that \( y \) denotes the cumulative number of slides presented by time \( t \)). Hence, utility is positive for \( 0 < y < a/b \), and increasing for \( 0 < y < a/2b \). As the number of slides presented increases, utility increases (concavely) to a maximum. Further increases of \( y \) result in declining utility and for sufficiently large values of \( y \), utility even becomes negative. These effects arise due to the following facts. Increasing the number of slides beyond reasonable limits creates bad-will in almost any audience. The attention is gradually lost, some people go to sleep, and others start to read newspapers, the next paper and so forth.

Now we formulate the Slidesman's objective. Assuming that he seeks to maximize total utility, but minimize waste in the form of unused slides, the objective functional becomes
\[
J = \int_{0}^{T} (ay - by^2) dt - kx(T).
\] (6)

Notice that the Slidesman has three control instruments: the presentation rate \( u \), the duration of the presentation \( T \), and the number of slides in stock \( N \). Also notice that \( N \) and \( T \), respectively, must be fixed optimally at \( t = 0 \) and cannot be changed in the course of the talk; they are constants. On the other hand, \( u \) is a time function, but \( u(t) \) must also be determined optimally at the start of the presentation. (One could consider the use of feedback controls, i.e. take \( u \) as a function of time as well as current state. However, in deterministic optimal control problems this leads to the same optimal path as the one obtained by assuming an open-loop formulation).

**Remark 1.** It is analytically convenient to treat the control parameter \( N \) as a degenerate state variable. Hence, \( N = N(t) \), and we impose the constraints
\[
N(0) \text{ free } (\Rightarrow N(T) \text{ free}), \quad \dot{N}(t) = 0 \quad \text{ for all } t.
\] (7)

### 3. Optimal Slidesmanship in Deterministic Conferences

In this section we first study a problem where strict adherence to the time limit is demanded such that the duration of the talk must not exceed \( \bar{T} \). Next, we analyze a variant of this problem, where a penalty term is introduced in the objective (6). Deviations from the limit \( \bar{T} \) are allowed, but punished by a quadratic function of the deviation. Finally, we propose an extension based on an assumption of a forgetful audience.

#### 3.1. The Case of a Rigid Chairman

Eliminating the variable \( y \), one obtains the following problem of optimal control.

**Problem 1 (P1)**
\[
\begin{align*}
\text{max} & \quad \int_{0}^{T} \left[ a(N-x) - b(N-x)^2 \right] dt - kx(T). \\
\text{subject to} & \quad \dot{x} = u \quad (8b) \\
& \quad \dot{N} = 0 \quad (8c) \\
& \quad x(0) = N(0) \quad (8d) \\
& \quad T \epsilon [0, \bar{T}] \quad (8e) \\
& \quad 0 \leq u \leq u_m \quad (8f) \\
& \quad x(T) \geq 0, N(T) \text{ free}. \quad (8g)
\end{align*}
\]

It is convenient to start the analysis by proving two propositions. These results confirm intuition and have also a certain amount of empirical support. Let an optimal value be denoted by a star.

**Proposition 1:** In problem P1, an optimal Slidesman extends maximally the duration of his presentation, that is, \( T^* = \bar{T} \).
PROOF: See Appendix 1.

The proposition states that it is not optimal to end a talk before the time limit \( T \). Hence, if one in practice observed a presentation with \( T < T \), then it may be concluded that this Slidesman was not an optimizer; rather he was guided by some irrational principle. (For example, his girl friend was impatiently waiting for him to come to an end, or his presentation was the last one before the coffee break (or lunch), or he realized that his car was illegally parked.)

**PROPOSITION 2:** In problem P1, an optimal Slidesman uses all his slides, that is, \( x^*(T) = 0 \).

**PROOF:** See Appendix 2.

This proposition states that it is never optimal to stop a talk having unused slides in stock.

Propositions 1-2 show that an optimal Slidesman is a genuine opposer of unnecessary waste. At the end of his talk he has neither time nor slides left. (The latter result obviously depends on the positivity of \( k \).)

After these preliminary steps we proceed with an analysis of the necessary conditions for problem P1, cf. Reference 2, § 7.4. Define the Hamiltonian

\[
H = H(x, N, u, \lambda_0, \lambda, \mu) = \lambda_0 (a(N-x) - b(N-x)^2) - \lambda u + \mu 0 .
\]

(9)

Let \( (x^*(t), N^*(t), u^*(t)) \) be an optimal triple for P1. Then there exist a constant \( \lambda_0 \leq 0 \), piecewise continuously differentiable costates \( \lambda(t), \mu(t) \) and constant multipliers \( \alpha \) and \( \beta \) such that for all \( t \in [0, T] \) it holds that

\[
(\lambda_0, \lambda, \alpha, \beta) \neq 0, \quad \text{and, except at discontinuity points of } u^*,
\]

\[
H(x^*, N^*, u^*, \lambda_0, \lambda, \mu) = \max \sum_{u \in u^*} H(x^*, N^*, u, \lambda_0, \lambda, \mu)
\]

(9a)

\[
H^* = \lambda_0 (a(N^*-x^*) - b(N^*-x^*)^2) - \lambda u^* = \text{constant}
\]

(9b)

\[
\dot{\lambda} = - \partial H/\partial x = - \lambda_0 (a-2b(N^*-x^*))
\]

(9c)

\[
\dot{\mu} = - \partial H/\partial N = -\lambda_0 (a-2b(N^*-x^*))
\]

(9d)

\[
\begin{bmatrix} \dot{\lambda}(0) \\ \dot{\mu}(0) \end{bmatrix} = \begin{bmatrix} 0 \\ -1 \end{bmatrix} \frac{\alpha}{\partial x(N)} ; \quad \beta = \text{const.}
\]

(9e)

\[
\lambda(T) = - \lambda_0 k + \alpha ; \quad \alpha = \text{const.} \quad u(T) = 0
\]

(9f)

\[
\alpha \geq 0, \quad x^*(T) = 0
\]

(9g)

\[
H(T^*) = \lambda_0 (a(N^*-x^*(T^*)) - b(N^*-x^*(T^*))^2) - \lambda(T^*)u^*(T^*) \left\{ \begin{array}{ll} \leq 0 & \text{if } T^* = 0 \\ \geq 0 & \text{if } T^* = T \end{array} \right.
\]

(9h)

**REMARK 2.** Notice in (9e) that \( \beta \) need not be non-negative. Moreover, by Proposition 2, we see that \( \alpha(T) = 0 \) is satisfied in (9g). Finally notice that \( H(T^*) \geq 0 \) holds in (9h) because of Proposition 1. In the sequel, where no confusion can arise, we often omit the star on an optimal value.

First we state some immediate consequences of the necessary conditions in (9). Using (9d), (9e), and (9f) yields

\[
\begin{align*}
(1) & \quad \int_0^T \dot{\lambda} dt = - \int_0^T \dot{\mu} dt = \mu(0) - \mu(T) = \mu(0) = \beta. \\
Eq. (9e) & \text{can also be written as}
\end{align*}
\]

(9i)

\[
\begin{align*}
(2) & \quad \lambda(0) = - \mu(0) = - \beta. \\
Using (9c,d) & \text{and (i) shows that}
\end{align*}
\]

(9j)

\[
\begin{align*}
(3) & \quad \int_0^T \dot{\lambda} dt = - \int_0^T \dot{\mu} dt = \int_0^T \dot{\lambda} dt = \lambda(T) - \lambda(0) = \lambda(T) + \beta
\end{align*}
\]

and using (i) yields

\[
\begin{align*}
(4) & \quad \lambda(T) = 0.
\end{align*}
\]

It is convenient to put \( \lambda_0 = 1.0 \). To do so, we establish

**LEMMA 1:** For an optimal solution to problem P1 it holds that \( \lambda_0 > 0 \).

**PROOF:** See Appendix 3.

Using (iii), Lemma 1, and (9f) yields

\[
\begin{align*}
(5) & \quad \alpha = k > 0.
\end{align*}
\]

This also confirms that \( x^*(T) = 0 \), cf. (9g) and Proposition 2.

We proceed to characterize an optimal solution. To maximize \( H \) with respect to \( u \) the Slidesman chooses

\[
u^* = \begin{cases} u_m & \text{if } \lambda = \lambda_0 < 0 \\ \text{singular} & \text{if } \lambda = \lambda_0 > 0 \end{cases}
\]\n
\[
\begin{align*}
(6) & \quad u^* = 0
\end{align*}
\]
Denote by \((x_s,u_s)\) a singular path for \((x,u)\). The singular control, \(u_s\), is characterized by

\[ \lambda = 0 \quad \text{and} \quad x_s = N - \frac{a}{2b}. \]

From (iii) we note that there must be a terminal interval, say, \([\tau, T]\) with \(u^* = u_s\). Since \(x^*(T) = 0\) by Proposition 2 we have \(x_s(T) = N - \frac{a}{2b} = 0\), implying \(N^* = a/2b\) and \(x_s = 0\). On the initial interval \([0, \tau]\) the Slidesman uses maximal efforts, i.e., \(u^* = u_{m}\) in order to reach the singular level \(x_s\) as fast as possible. On this interval it holds that

\[ x^*(0) = N^* = a/2b \quad ; \quad x^*(t) = N^* - u_{m} t, \]

and the costate \(\lambda\) is negative. It increases toward zero according to

\[ \lambda = (a - bu_{m})t - \frac{a^2}{4bu_{m}}. \]

The switching instant \(\tau\) is given by

\[ \tau = \frac{a}{2bu_{m}} \quad (10) \]

and we have to assume that \(u_{m} \tau > a/2b\). This means that \(\int_{0}^{T} u_{m} dt > N\). Thus, presenting slides at the maximal speed for all \(t\) will (more than) exhaust the stock of slides. This assumption does not seem unreasonable. Otherwise, the optimal solution is \(N^* = u_{m} \bar{t}, x^* = N^* - u_{m} t, u^* = u_{m}\) for all \(t\) and there is no singular solution.

To summarize, an optimal solution of problem \(P1\) is characterized by the bang-bang policy.

\[ u^* = u_{m} \quad \text{on} \quad [0, \tau] \quad ; \quad u^* = 0 \quad \text{on} \quad [\tau, T]. \]

It is an easy task to verify that the sufficient conditions are satisfied. Hence, the solution is indeed optimal. In Figure 1 we have depicted the time paths for state and costate for problem 1 (and problem 2, see Section 3.2).

Notice that there is no terminal cost \((kx(T))\) involved since \(x(T)\) equals zero. It is optimal to approach as rapidly as possible the (singular) level \(y_s = a/2b\), where marginal utility \((U'(y))\) equals zero. Hence \(U(y)\) is maximal. This is accomplished by putting \(u^* = u_{m}\) until \(y\) reaches the level \(y_s\). The initial policy \(u^* = u_{m}\) means that slides are being shown in very fast succession, producing a hypnotic and exhausting effect upon the audience.

Admittedly, the solution may seem somewhat unrealistic because of the terminal interval where apparently nothing is presented. We may, however, assume that this amounts to presenting the very last slide on the entire interval from \(\tau\) to \(T\). Then the solution can be interpreted as follows. The Slidesman presents his slides very rapidly on an initial interval, but eventually he runs out of slides and has to stick to his very last slide for the rest of the talk. Here, a "Time Lapse" technique may be appropriate. The trick is to present precisely the same slide again and again; the comments may also be the same. The explicit purpose of the Slidesman is, however, to point out the very sharp distinction between the situations shown in the slides. The effects
of this technique can be remarkable, and the distinguished persons in the front row will nod in more and more vigorous assent.

**Remark 3.** It is possible to interpret the model of Section 3.1 in the context of a non-renewable resource problem. Consider the following scenario. A firm has a contractual right to extract a certain amount \( N \) of a resource in the period \([0, T]\) such that extraction must stop at latest at time \( T \). Contrary to what is normally assumed, the initial stock of resources \( x(0) \) is not exogenously fixed but must be (optimally) determined by the firm. In problem \( P_1 \), Eq. (8b) is the usual state equation and (8f) is also a standard assumption. In the payoff (8a) we can think of \( k \) as an opportunity cost of one unit in stock at time \( T \). Hence, one assumes that an unextracted reserve, \( x(T > 0) \), cannot be transferred to a following extraction period. The payoff integral in (8a) assumes that utility (or profit) depends on cumulative extraction \( y \) rather than on the extraction rate \( u \). The objective of the firm is to maximize (undiscounted) utility over the extraction period and minimize the terminal loss. The firm decides on (i) how large a share of the resource it will contract \( N \), (ii) the rate of extraction \( u \) and (iii) when to terminate extraction \( T \).

### 3.2. The Case of a Sloppy Chairman

In this section we assume that strict adherence to the time limit \( T \) is not demanded. Hence, disregard the constraint \( 0 \leq T \leq T \). However, as mentioned in Section 2, deviations from \( T \) will be penalized in the objective functional (6). Define the problem

\[
P_2 \quad \max_{u, T} \int_0^T \left[ a(N-x) - b(N-x)^2 \right] dt - kx(T) - c(T-T)^2
\]

subject to (8b), (8c), (8d), (8f), (8g).

The solution of \( P_2 \) is the same as that of \( P_1 \), with the exception of \( T^* \). In the necessary conditions, (9h) in \( P_1 \) must be replaced by

\[
H^*(T^*) = 2c(T^* - T) = \frac{a^2}{2b} - \frac{b}{2} \left( \frac{a}{2b} \right)^2
\]

which implies

\[
T^* = T + \frac{a^2/4b}{2c}
\]

where \( a^2/4b = U(N^* - x_s) \) is the utility corresponding to the singular \( y \).

Recall that \( T^* = T \) in \( P_1 \). The result in (11) shows that in \( P_2 \) the presentation is always extended beyond the limit \( T \); this seems to confirm the experience of Conferecenmen. The optimal time of termination in \( P_2 \), of course, tends to \( T \) as \( c \) increases, i.e. as the penalty for deviations from \( T \) increases. But the time limit \( T \) may be considerably exceeded if the penalty is small. (A low penalty \( c \) is involved if, for instance, the chairman falls asleep, or the next two papers are cancelled). The results of \( P_2 \) should serve as a warning to chairmen not to be too liberal with unpunctual slidesmen.

### 3.3. Optimal Slidesmanship With a Forgetful Audience

In this section we modify the model by introducing a second state equation. This is done in order to account for the fact that audiences, in general, are forgetful. From Section 2 we have Eq. (2)

\[
\dot{x} = -u \quad \dot{y} = u
\]

Recall that \( y \) is the cumulative number of slides presented by time \( t \). Taking \( (2) \) as our starting point, we introduce a new state equation (apart from \( (2) \) which must always hold). Let this state equation be given by

\[
\dot{y} = -y - \delta y \quad \delta = \text{constant} > 0
\]

The following interpretation applies to (12). We may regard \( y \) as an 'exposure level', that is, the number of slides still kept in mind by time \( t \) by an average member of the audience. The slides that have been presented are gradually forgotten which is modelled by exponential decay. But such decay can be neutralized by showing new slides; this accounts for the term \( u \) in (12).

Incorporating the new state equation (12), two control problems can be formulated.

**Remark 4.** We omit the degenerate state \( N \) by letting \( x(0) \) be free.

\[
P_3 \quad \max_{u, T} \int_0^T \left[ (ay - by^2)dt - kx(T) \right]
\]

subject to

\[
\dot{x} = -u \quad x(0) \text{ free}
\]

\[
\dot{y} = -\delta y \quad y(0) = 0
\]

\[
0 \leq u \leq u_m
\]

\[
x(T) \geq 0 \quad y(T) \text{ free}
\]

\[
T \in [0, T]
\]
Notice that P3 is simply P1 extended with (12). Furthermore, define

\[ P_4 \quad \max_{u, T} \int (ay - by^2) dt - k(T) - c(T-t)^2 \]
subject to (13b), (13c), (13d), (13e).

Notice that P4 is simply P2 extended with (12).

The analysis of problems P3 and P4 resembles very much that of problems P1 and P2. We only state the main results. It turns out that also in P3 and P4 it holds that \( x^*(T^*) = 0 \). The optimal solution is again a MRAP (Most Rapid Approach Path) to the singular level \( y_s = a/2b \).

However, the singular control in P3 and P4 is non-zero. Due to the decay term, the singular control, \( u_s \), is positive. It is given by

\[ u_s = \frac{\delta y_s}{2b} \quad \text{on the interval } [\tau, T^*]. \]

Hence \( x_s = u_s (T^* - t) \) and the switching instant, \( \tau \), is given by

\[ \tau = -\frac{1}{\delta} \ln(1 - \frac{\delta a}{2bu_m}) \]

which is smaller than the switching instant in P1-P2 (cf. (10)). Thus, a Slidesman facing a forgetful audience should switch from maximal to singular efforts at an earlier instant than otherwise.

As to the optimal number of slides to prepare, \( N^* \), recall that \( N^* = a/2b \) in P1 and P2. For problems P3 and P4 we obtain

\[ N^* = \tau u_m + (T^* - \tau) \frac{\delta a}{2b}. \]

It is easy to prove that \( N^* \) given by (15) is greater than \( a/2b \). Hence, in case of decay due to forgetting the Slidesman should prepare more slides than if there is no such decay.

The solution of problems P3 and P4 is depicted in Figure 2. The main differences between cases with decay, and cases without decay, are the following:

- In case of decay due to forgetting, then the optimal number of slides to prepare is greater than that in a case of no decay. This confirms intuition.
- In case of decay, then the (singular) presentation rate, \( u_s \), is positive on the terminal interval; in case of no decay \( u \) is zero on such an interval. The terminal interval with singular control is longest in the case of decay.

4. CONCLUSIONS

In this paper, we have studied some aspects of slidesmanship. Under the assumption that the Slidesman recognizes the importance of such variables as the number of slides to prepare, their timing and when to stop, we developed optimal strategies for these variables.

A number of easily applicable strategies have been delineated:

1. When the Rigid Chairman declares the time limit be absolutely fixed, then an optimal Slidesman extends maximally the duration of his talk. Moreover, he should use all the slides that were prepared for the session. The timing of the presentation should be done in such a way that slides initially are presented at maximum speed; from the instant where he runs out of slides, the Slidesman should apply Time Lapse (or any other appropriate technique).

A widespread implementation of this strategy would certainly change the universe of conferences. Until now, we have seen unexperienced or even poor slidesmen who give very detailed explanations to every single slide and, therefore, only progress very slowly. However, these (suboptimal) Slidesmen eventually realize that time is running (out) and that they have spent almost the whole time by showing a few, introductory slides. At this instant it is, sadly enough, too late to remedy anything, and the Slidesman ends his talk by show-
ing slides very superfluously and at an almost infinite speed; most of the slides he prepared for the session remain unused.

(2) Facing a Sloppy Chairman an optimal Slidesman always extends his talk if the cost of doing so is not infinitely high. The policy is the same as in (1), but the terminal interval with the single-slide presentation is longer. This is not a disadvantage since it gives the Slidesman ample time to summarize his findings and give directions for future research.

(3) When a Slidesman foresees that he will be facing a Forgetful Audience, then he should prepare more slides than otherwise. Also, he should continue to present slides during the whole time scheduled for presentation. Both policies seem appropriate in an effort to counteract the decay effects that stem from the moderate intellectual capability of an average conference man.

In this paper we have focused on a few, but important, issues related to Scientific Slidesmanship. Many interesting aspects had to be put aside, not for some obscure reason of 'mathematical tractability', but simply because of space limitations.

Optimal slidesmanship is an area where the avenues for future research are almost unlimited since the field is in strong need for research of prescriptive as well as empirical significance. We shall make a few proposals for new investigations.

* No Slidesman is a Robinson Crusoe. (Although in practice some slidesmen actually think they are). Any Slidesman, experienced or not, must make his presentation in an environment of other decision makers. Hence, the Slidesman's dynamic decision problem should be embedded in a more general framework, using e.g. differential game theory. In a session, at least three types of players (with partly conflicting interests) are present: the Slidesman, the Chairman and the Audience (and probably more). Differences in objectives for these groups are evident and give rise to a number of interesting questions.

* The Dynamics of Slidesmanship can be refined. In this paper, we have assumed rather simple descriptions of the system. Hence, a multitude of extensions exist and should definitely be explored. Partial differential equations may be a convenient vehicle to accomodate for other variables than just time. The quality of the slides is an important variable which is bound to influence the audience (and the chairman, and maybe also the Slidesman himself). But production of high quality slides can only be affected at high costs. This leaves the Slidesman with a variety of options; see also Section 1.

* Stochastic elements can be introduced in the model. In practice, a Slidesman will not know, at time t = 0, exactly when the chairman decides to put an end to the presentation. Hence, the Slidesman must cope with an Unpredictable Chairman and the actual duration of the talk will be a random variable. Such an extension is considered by the authors in a paper forthcoming in Optimal Control Applications & Methods.

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REFERENCES


APPENDIX 1. Proof of Proposition 1

Assume that \((x^*, N^*, u^*)\) is an optimal triple such that \(T^* < T\). Since \(x(0) = N \iff y(0) = 0\), there exists a \(\tau \in [0, T^*]\) such that \(0 < y(\tau) < a/b\), that is, \(U(y(\tau)) > 0\).

On the interval \([0, T^* + \epsilon]\) define another triple \((x^{**}, N^{**}, u^{**})\) such that \(N^{**} = N^* + \epsilon\) and

\[
\begin{align*}
    \bar{u}^{**}(t) &= \begin{cases}
        u^*(t) & 0 \leq t < \tau \\
        u^*(t) & 0 \leq t \leq T^* + \epsilon
    \end{cases}
    \end{align*}
\]

Then, for \(\epsilon > 0\) and sufficiently small, the solution \((x^{**}, N^{**}, u^{**}, T^* + \epsilon)\) is feasible and

\[
    J(u^{**}, N^*) = J(u^*, N^*) + \epsilon \cdot U(y(t)) > J(u^*, N^*)
\]

Hence, \((x^*, N^*, u^*, T^*)\) cannot be optimal with \(T^* < T\). Q.E.D.

APPENDIX 2. Proof of Proposition 2

Assume that \((x^*, N^*, u^*)\) is optimal on \([0, T]\) such that \(x^*(t) \geq x^*(T) > 0\) for all \(T\). Define a new triple \((x^{**}, N^{**}, u^{**})\) where

\[
    u^{**} = u^*, \quad x^{**} = x^* - x^*(T), \quad N^{**} = N^* - x^*(T)
\]
Then the new triple yields the same value for the integral in the objective functional. Hence

$$ J(u^{**},N^{**}) = J(u^*,N^*) + kx^*(T) > J(u^*,N^*) $$

which shows that $(x^*,N^*,u^*)$ cannot be optimal, and we conclude that $x^*(T) = 0$. Q.E.D.

APPENDIX 3. Proof of Lemma 1

We prove the lemma by contradiction. Assume that $\lambda_0 = 0$. From (9d) and (9f) we obtain $\mu = 0$ for all $t$. Hence, by (9e), the multiplier $\beta$ must be zero. From (9c) we have $\lambda = 0$ for all $t$ since $\lambda(0) = -\beta = 0$, and $\gamma = 0$ for all $t$. Then, (9f) shows that $\alpha = 0$ because of $\lambda(T) = 0$. Now, $(\lambda_0,\lambda,\mu,\alpha,\beta) = 0$ which contradicts the necessary condition that all multipliers do not vanish simultaneously. Q.E.D.