Transatlantic robot-assisted telesurgery

ATM technology now enables operations to be performed over huge distances.

The introduction of robotic and computer technology into surgical operations allows dexterity to be increased and surgical procedures to be carried out from a distance (telesurgery). But until now, the distance feasible for remote telesurgery was considered to be limited to a few hundred miles by the time lag of existing telecommunication lines. Here we show that robot-assisted remote telesurgery can be safely carried out across transoceanic distances. The ability to perform complex surgical manipulations from remote locations will eliminate geographical constraints and make surgical expertise available throughout the world, improving patient treatment and surgical training.

Telemotorizing and limited surgical assistance over long distances have been reported, but technical limitations have so far prevented the performance of a complete operation. Telesurgery was expected to involve only telementoring, rather than remote manipulation, for the foreseeable future. Limiting factors have been the time for converting video images and surgical movements into electronic signals, and the bandwidth and time delay of existing telecommunication lines.

To investigate the impact of variable time delays on surgical manipulations, we carried out robot-assisted laparoscopic cholecystectomy (gall-bladder removal) on a pig, transmitting the signals from the surgeon’s console in Strasbourg, France, to Paris and back — a total distance of about 1,000 km. The time lag was artificially increased from 20 milliseconds (standard time delay) up to 551.5 ms. The limit of the acceptable time delay in terms of a surgeon’s perception of safety was roughly 330 ms.

To measure transoceanic latencies and verify the feasibility of an intercontinental surgical operation, we attempted robot-assisted laparoscopic cholecystectomy in a porcine model across a round-trip distance of over 14,000 km. The operator site was located in New York and the animals were in Strasbourg.

The robotic system (ZEUS, Computer Motion, California) consisted of two separate subsystems (‘surgeon-side’ (Fig. 1) and ‘patient-side’ (Fig. 2)). The two sites were connected through a high-speed terrestrial optical-fibre network (FranceTelecom/Equant) that transports data through dedicated connections using asynchronous transfer mode (ATM) technology. A bandwidth of 10 megabits per second has been reserved through a network that interconnects applications at both sites using a network termination unit (NTU), which provides a multiservice path to different applications.

To monitor and measure its level of quality, the NTU sender inserted ‘operating and maintenance’ packets within user data flow, which were extracted and analysed by the remote NTU receiver. By analysing these packets and comparing the number of user packets initially sent to those that were actually received, we determined the number of lost packets.

Operation and maintenance tools revealed that no ATM packet was lost during any surgical procedure. The round-trip delay by ATM transport was 78–80 ms. Adding 70 ms for video coding and decoding, plus a few milliseconds for rate adaptation and Ethernet-to-ATM packet conversion, movements executed by the surgeon in New York were apparent within 155 ms on his video screen.

We successfully carried out laparoscopic remote robotic cholecystectomy in six pigs. The operator site was located in New York, and the animal sites were in Strasbourg.

The three surgeons in New York subjectedively evaluated, in a blinded manner, the quality of the image, the impact of time lag on performance, the coordination and safety of the use of electrocautery, and the overall safety of the procedure. Evaluation was on a 0–10 scale (where 0 is the worst possible and 10 the best possible). Scores were 9.1 for the quality of image, 8.5 for the impact of time lag, 0, unacceptable impact; 10, imperceptible impact), 9.2 for coordination of electrocautery, and 8.7 for overall safety. These scores reflect the high confidence of the surgeons in controlling the surgical movements as well as the general reliability of the system.

Note added in proof: We have successfully carried out a remote laparoscopic cholecystectomy in a 68-year-old female after obtaining ethical committee approval and informed consent from the patient. The surgeons were in New York and the patient was in Strasbourg. The circuit used was the same as the one described here; the mean total time delay was 155 ms. The time taken to set up the robotic system was...
Cyanobacteria track water in desert soils

Cyanobacteria develop as large, cryptic populations in the topsoil of arid land, where plant cover is restricted, water is scarce and harsh microenvironmental conditions prevail. Here we show that some cyanobacteria can actively move in response to wetting or drying events by migrating to the soil surface or retreating to their refuge below. This ability to follow water, which to our knowledge has not been demonstrated before in microbes, may turn out to be important for microbial terrestrial populations in general.

Although cells direct their movements in response to environmental stimuli, so far no microorganism has been shown to exhibit a tactic response to water, perhaps the most crucial molecule in biology. We tested the response to soil wetting of cyanobacteria — important primary producers in topsoils that support only sparse plant growth, notably in hot and cold deserts — and found that they move away from surface-desiccation fronts. This behaviour, together with a tactic response to light, results in vertical migration patterns that probably optimize the position of these microorganisms in the soil matrix for incoming drought periods, thereby contributing to their success in harsh habitats.

Using microscale measurements of surface spectral reflectance, we monitored the vertical migration of cyanobacteria in samples of arid soil from badlands in Spain. This soil, in its original desiccated state, contained a subsurface population of a filamentous oscillatorian cyanobacterium (Oscillatoria sp.; estimated population maximum at a depth of about 2 mm).

Greening of the surface was evident within minutes of wetting (Fig. 1a) and increased linearly for up to 2 hours. Microscopic observation of wetted samples showed that this greening was due to the appearance of cyanobacterial filaments at the surface (Fig. 1b, c). The greening could be slowed or prevented by exposing the soil to high-intensity light, indicating the involvement of cellular photoresponses, but also occurred in the dark (data not shown), as found previously for cyanobacteria in other habitats.

When the soils were allowed to dry under unchanged illumination, the greening stopped and eventually reversed, with the cyanobacteria apparently moving downwards. This reversal also took place in complete darkness. Upward and downward migrations could be induced repeatedly (Fig. 1d) by wetting and drying cycles. We conclude that the greening reversal is not due to a photoresponse or to a chemoresponse to oxygen, pH or CO2 gradients, which are opposite under dark and light conditions.

When inhibitors of cellular ATP generation were added to the soil (Fig. 1e), the greening reversal was completely inhibited, indicating that cellular energy is required to sustain gliding motility. The cyanobacterial retreat is therefore unlikely to be a purely physical effect driven by surface tension at the air–water interface. Our evidence indicates that this cyanobacterium can either sense changes in water availability and respond with tactic behaviour, or can hold itself in a wet environment.

In this cyanobacterium, this behaviour overwhelmed the tendency to seek optimal illumination, which would otherwise keep the population at the soil surface. The cyanobacteria are thus able to reach new refuges and are less likely to be trapped in a desiccated, near-surface environment. This serves to reduce population photodamage and losses through erosion, and to increase survival during drought periods.

Cells may sense short-term changes in external water availability, perhaps through mechanosensitive channels, which may
differential genetic imprinting, as well as on the amount of gene product needed for biological function.

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Vielle-Calzada et al. reply — Our results, based on a study of 20 loci, indicate that the contributions by the maternal and paternal genome to early seed development in Arabidopsis are not equivalent, as evidenced by a lack of detectable paternal gene activity during the first few divisions after fertilization. As these loci are distributed throughout the genome, we inferred that early embryo and endosperm development are mainly under maternal control, but this may not be the case for every locus and, as in X-chromosome inactivation, we would expect some loci to escape this silencing mechanism. We did not claim that maternal control is complete, but suggested that the activity of many genes during early development and endosperm formation could depend solely on transcription of the maternally inherited allele before and/or after fertilization.

Previously, early seed formation was thought to involve transcription from both parental copies immediately following fertilization, and maternal effects were considered rare or non-existent. The time at which paternal activity can first be detected, however, is likely to vary from embryo to embryo and from gene to gene in different nuclei, as in Drosophila. Weijers et al. report parental expression of ATRPSA::GUS as early as the two-cell stage, confirming that transcription in the zygote is not the rule for paternally inherited alleles, whereas transcription from maternal alleles has been demonstrated immediately after fertilization of the central cell. We do not know what percentage of embryos show early ATRPSA::GUS expression, nor the relative paternal and maternal activity, but there may also be less pronounced parent-of-origin differences.

Night-time predation by Steller sea lions

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We stated that our acoustic surveys in Prince William Sound since 1993 and infrared surveys since 2000 suggested that these sea lions “feed exclusively” on herring. However, it has been drawn to our attention that this statement is misleading. In clarification, the sea lions were selectively targeting the relatively shallow (0–50 m depth) schools of Pacific herring (Clupea pallasii) at night as a source of winter forage to the exclusion of relatively larger and deeper (150–250 m) concentrations of walleye pollock.

New evidence supporting the non-equivalence of maternal and paternal genomes during early seed development is based on experiments with reporter genes and genetic assays revealing maternal effects of genes thought to act purely zygotically (S. Gilmore and C. Somerville, personal communication; J. Moore and U. G., unpublished results). Whether and at what stage expression of the paternal allele is sufficient for normal development will depend on the level of activity required for gene function. In a two-component transactivation system, no paternal activity was found during early seed development using pO::GUS reporter lines with several activator lines. Some early defects were evident with a pO::BARNASE reporter, however, suggesting that paternal transcription is very low but is sufficient to cause BARNASE-induced defects in some embryos. These results confirm the non-equivalence of maternal and paternal contributions to early seed development. Like imprinted genes in mammals, this difference is probably not absolute and may be due to different levels of maternal and paternal transcripts.

Our titration experiments indicated a difference in transcript levels of at least 80-fold for genes we tested by PCR. Weijers et al. report an expression difference in reciprocal crosses with UAS::GUS at the heart to torpedo stage (Fig. 3d), where we showed that both parental alleles are active at allele loci we tested; indeed, this differential expression translates into an absence of detectable paternal activity at earlier stages using the pO::GUS reporter system. For some genes, such as KEULE or KNOLE, low paternal expression may be sufficient for normal development, although very early defects (such as developmental delay) that are rescuable by a paternal wild-type allele may be difficult to detect by scoring multinucleate embryos. Moreover, rescue of an early embryonic phenotype by a paternal wild-type allele provides no evidence against differences in parental transcript levels.

Although the exact time of paternal activation was not central to our report, most evidence so far suggests that no consistent paternal gene activity can be detected in the embryo or endosperm for several cell divisions. The results of Weijers et al. do not contradict our findings, but instead represent possible exceptions to a general rule. Specific genes that are important during early development (for example, those involved in cytokinesis that are distinctly regulated in the female gametophyte and the zygote) may be under selection for earlier expression and be specifically activated early in development. Further investigation is required into how common early-expressing paternal genes are, and how maternal and paternal expression differ quantitatively.

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Peptide antibiotics in mast cells of fish

Umaporn Silphaduang, Edward J. Noga


The concentrations listed in Table 1 are in μg ml⁻¹.

erratum

Nitrate flux in the Mississippi River

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In Fig. 1 of this communication, the line referred to as “black” is in fact blue; also, in the fourth line of the third column, P should be greater than 0.05.