The following is taken from my annual internal CV at CMU, January 2011. It describes new research results over the past year. (Please excuse the "I" narration.)

- I showed how homology and cohomology generators in a strategy complex describe an adversary's power to force a system towards particular states.

  These observations lead to a higher-order perspective of adversarial interactions. The strategies in a strategy complex consist of collections of actions describing an eventually convergent control law. Once one has a description of strategies one can forget the constituent actions, instead viewing the strategies as "primitives" (this idea is captured by another simplicial complex I call a "source complex"). The question of who has control, the system or the adversary, then becomes a game of patience. The player who "blinks" first, loses, so to speak. More specifically, the source complex factors into simpler complexes. One factor describes states that the system can always avoid stopping at. The other factors describe equivalence classes of the transitive closure of a simple relation in which two states are related whenever they lie in a common minimal nonface of the source complex. The adversary can, over time, force an impatient system to move to any state within whatever equivalence class the system resides in initially.

- I established connections between network codes and strategy complexes. A key result is that one may view the creation of a linear network code over a finite field for an acyclic multicast network with uniform demands as motion planning with both control and sensing uncertainty. Control uncertainty models transmission failures; sensing uncertainty models the requirement that the code be invertible no matter which transmissions succeed.

- In early summer 2010, I revisited the design problem. I showed how improving or speeding up system capabilities may be viewed as plugging holes in the surface of a sphere. For the classic 2D peg-in-hole problem, the alternative of either moving far from the hole or introducing a force sensor to detect entry into the hole, follows naturally from this design philosophy.

- In summer and fall 2010, I revisited the problem of force-closure grasping, now from a topological perspective. One of my goals is to reduce the need for explicit shape models. I would like for robots to manipulate objects using functional models directly rather than build shape intermediaries when those are unnecessary. My approach is to model the combinatorics of contact, then embed the resulting combinatorial structures in force space and see what happens. To that end, I defined yet another simplicial complex, whose simplices are collections of contacts that do not form force-closure. Instead of an explicit shape model, one views a (discretized) object as a force-closure complex. The dimension of the force space associated with an object constrains the possible force-closure complexes. Those constraints translate into grasping results. For instance, it turns out that in pure 2D (no torques, just forces) it is impossible for a robot to construct an even-length circulating finger gait of length greater than four in which successive pairs of contacts form force-closure but no other pairs of contacts form force-closure. Another example: when grasping a 2D rigid object subject to both forces and torques, if one has a four-finger force-closure grasp on the object, then one can put down a fifth finger anywhere on the object and be sure either of establishing an equilibrium grasp using some set of three of the five fingers or of forming a new force-closure grasp with some set of four of the five fingers different from the original four fingers.