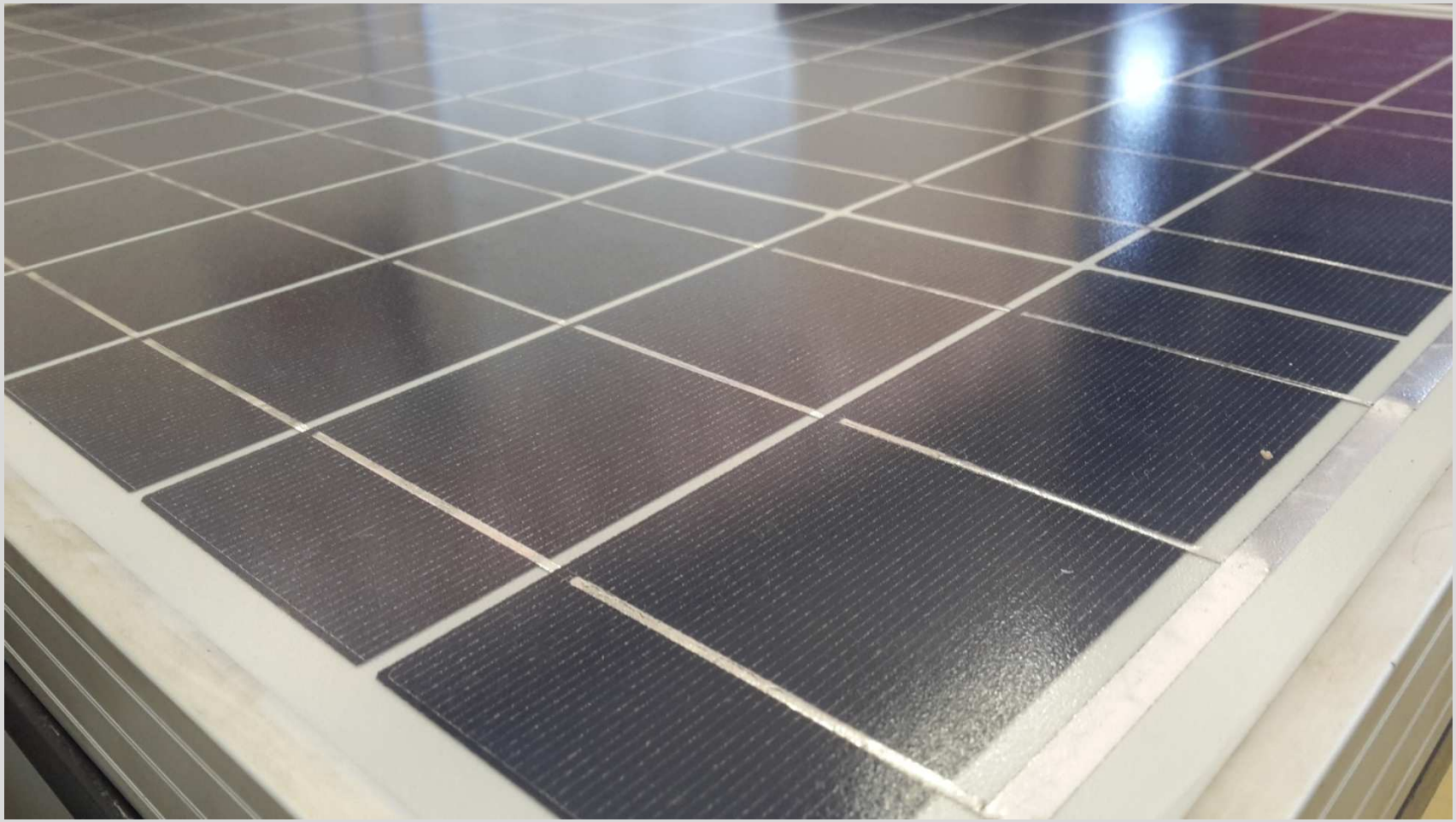
Lab Control: Research center at UTFPR

- **Lab Control** is a research laboratory located at the CIPECA buildig, Universidade Tecnológica Federal do Paraná (UTFPR), Brazil.

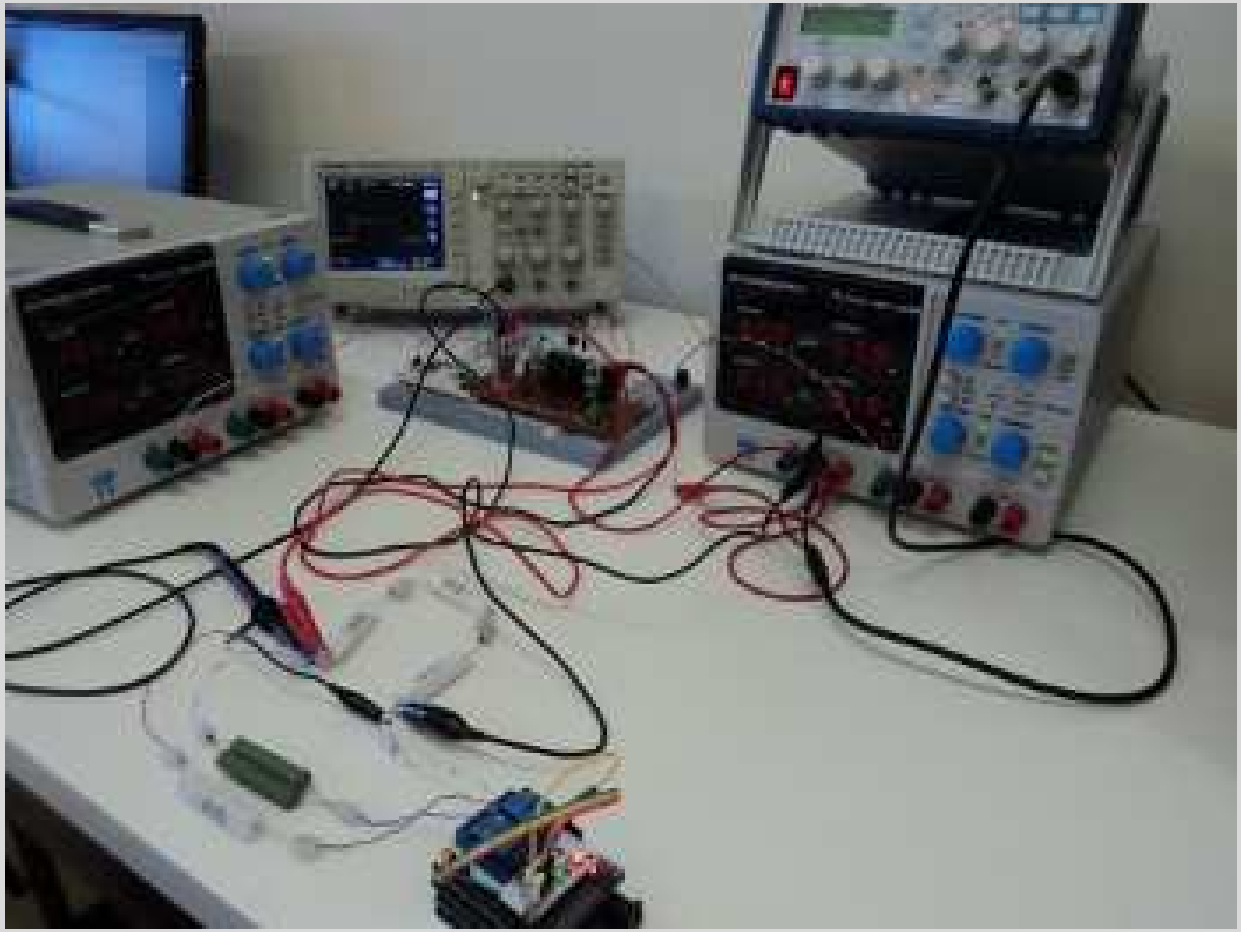
- **Lab Control** has a team composed by researchers and students (undergraduate, master and doctorate students).

- Join us at **Lab Control**.

- **Lab Control** — research on renewable energy: photovoltaic panels to produce electricity.

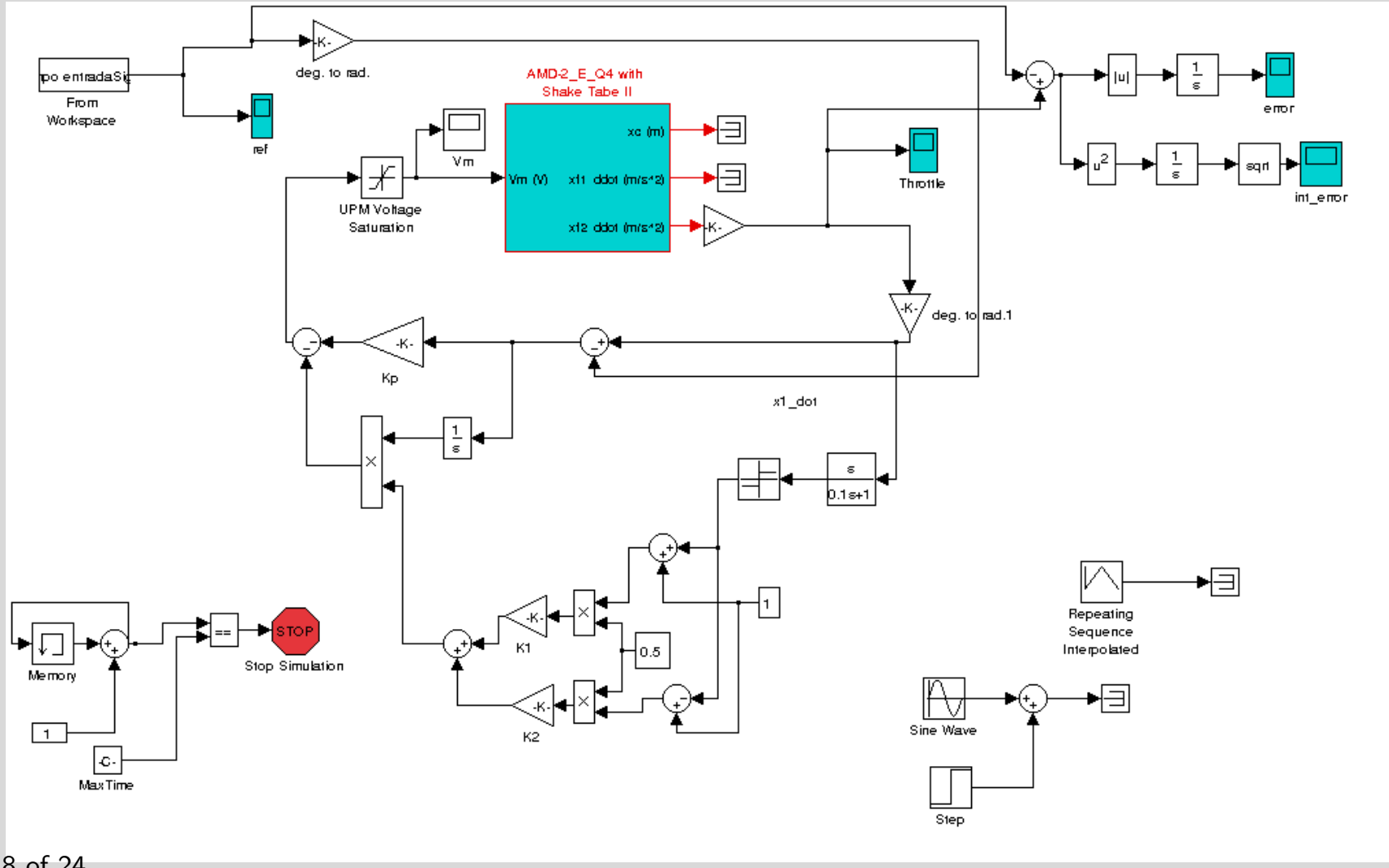


- **Lab Control** — research on renewable energy: electronic devices used to convert electricity.

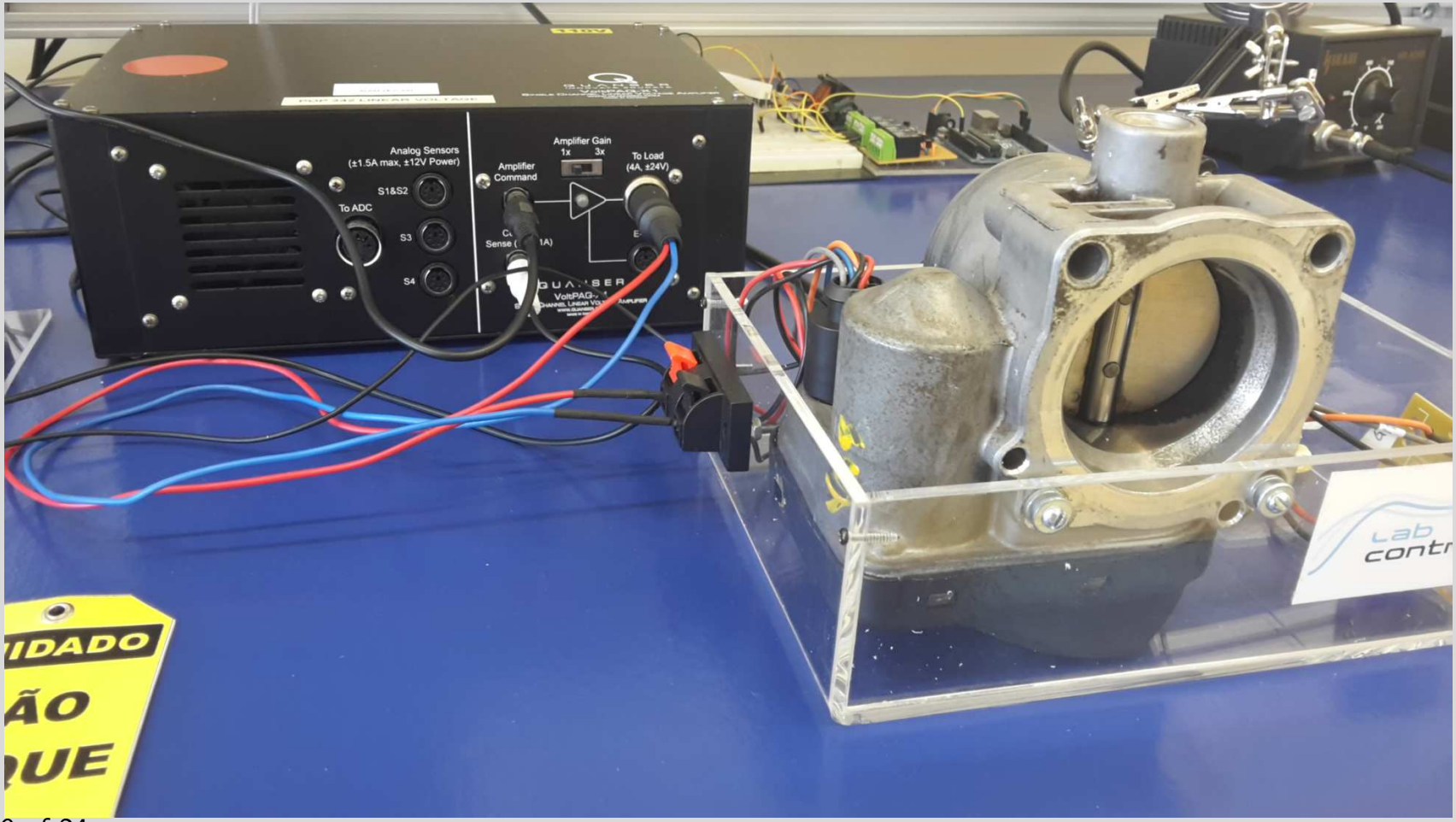


- **Lab Control** — research on renewable energy: control of wind turbines.

- **Lab Control** — research on renewable energy: control of wind turbines via simulation on PC.

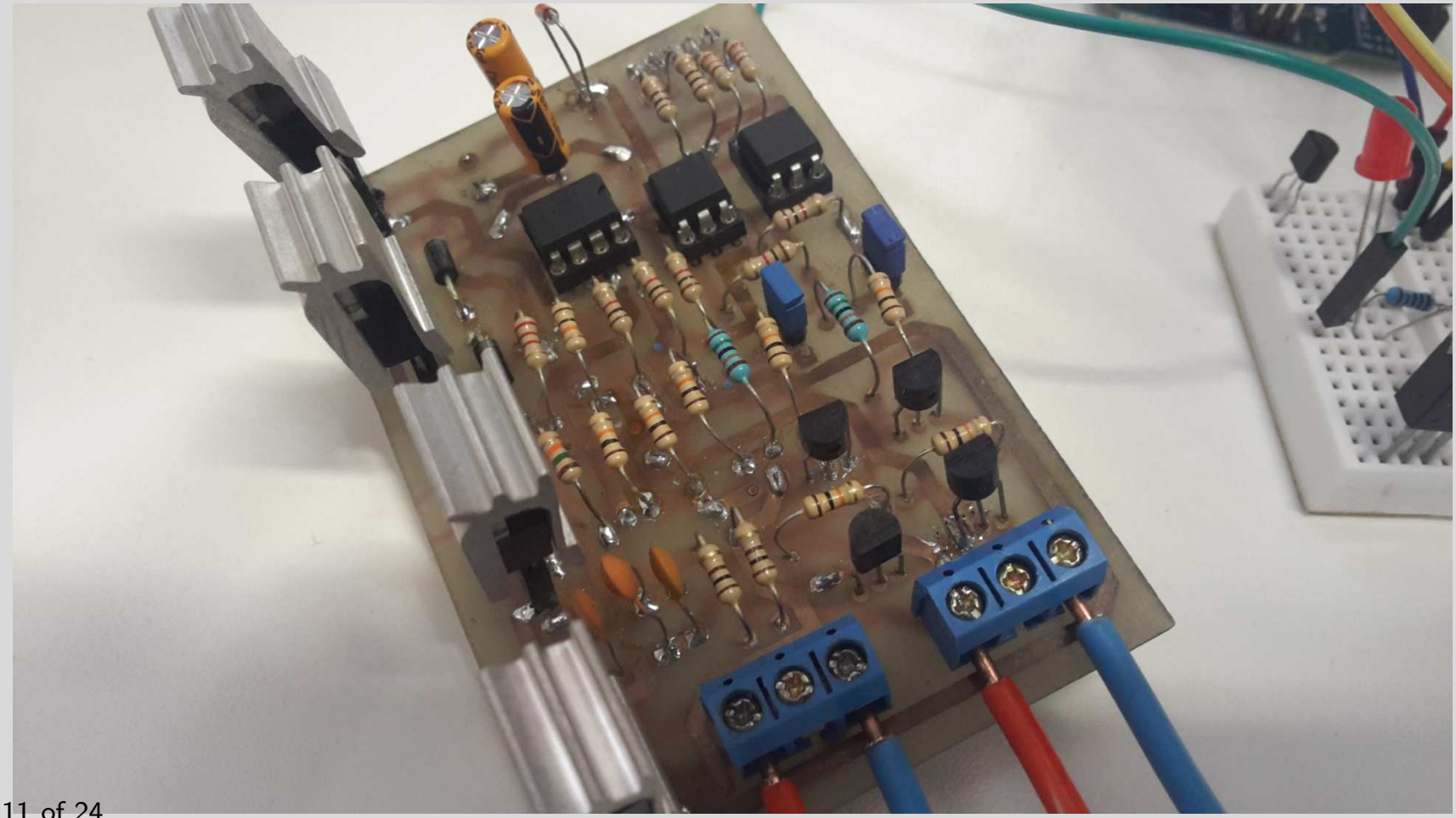


- **Lab Control** — research on automotive systems: electronics to support the experiments for a throttle device.

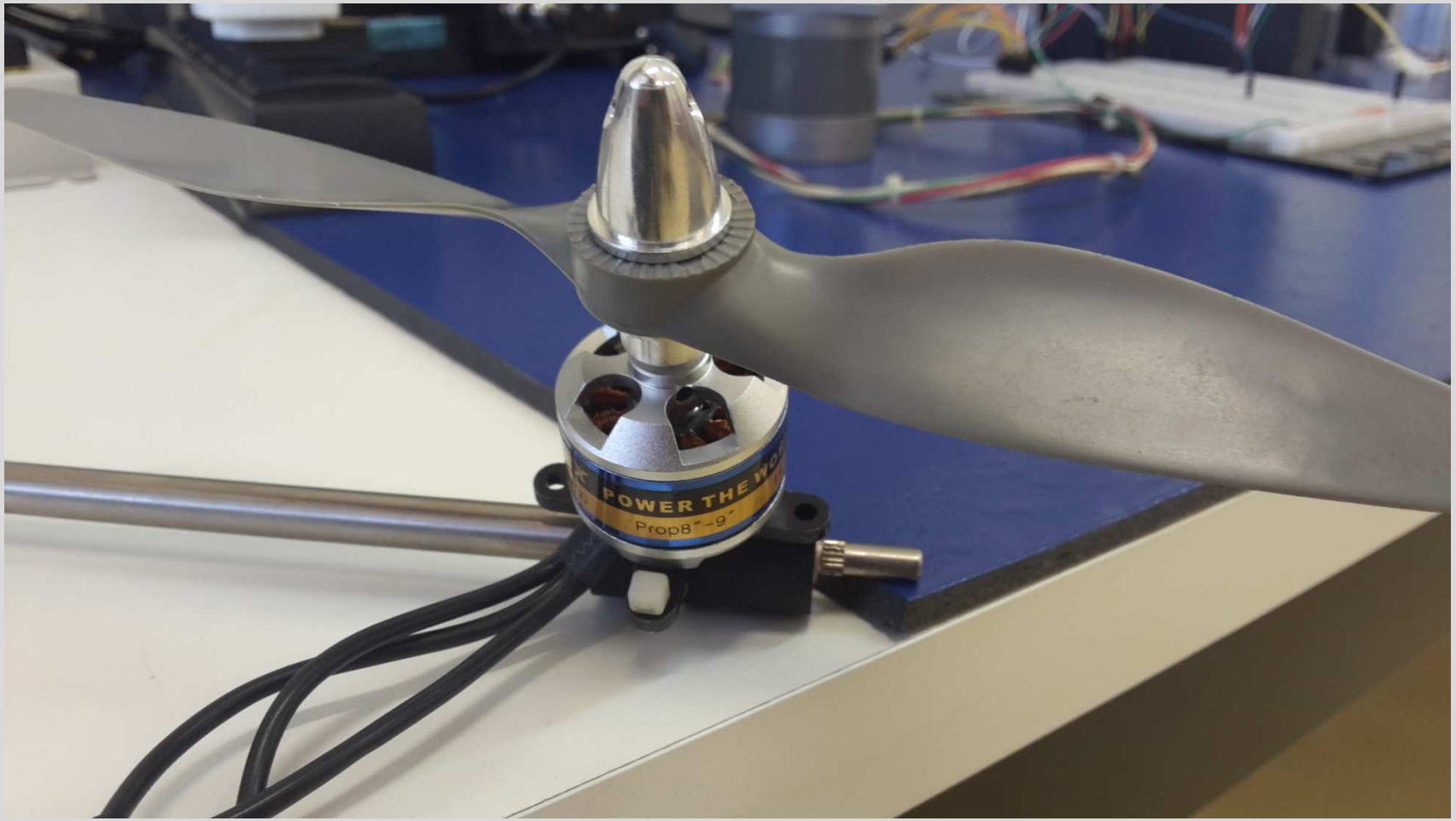


- **Lab Control** — research on automotive systems: automatic control for mecanical steering linkages—the wheels follow the pilot's command.

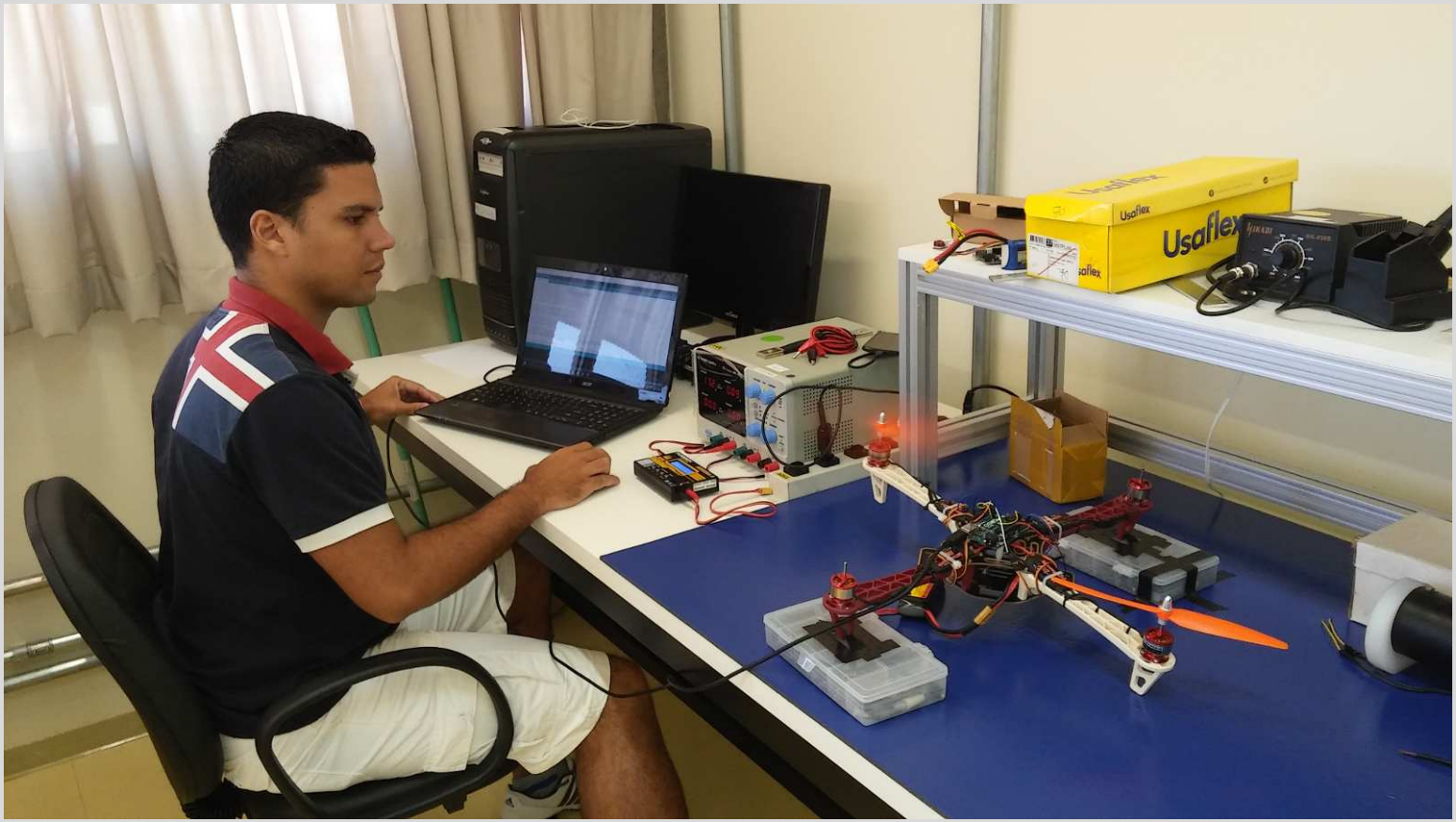
- **Lab Control** — research on automotive systems: Prototype of a board that actuates on the DC motor of the Power Steering system.



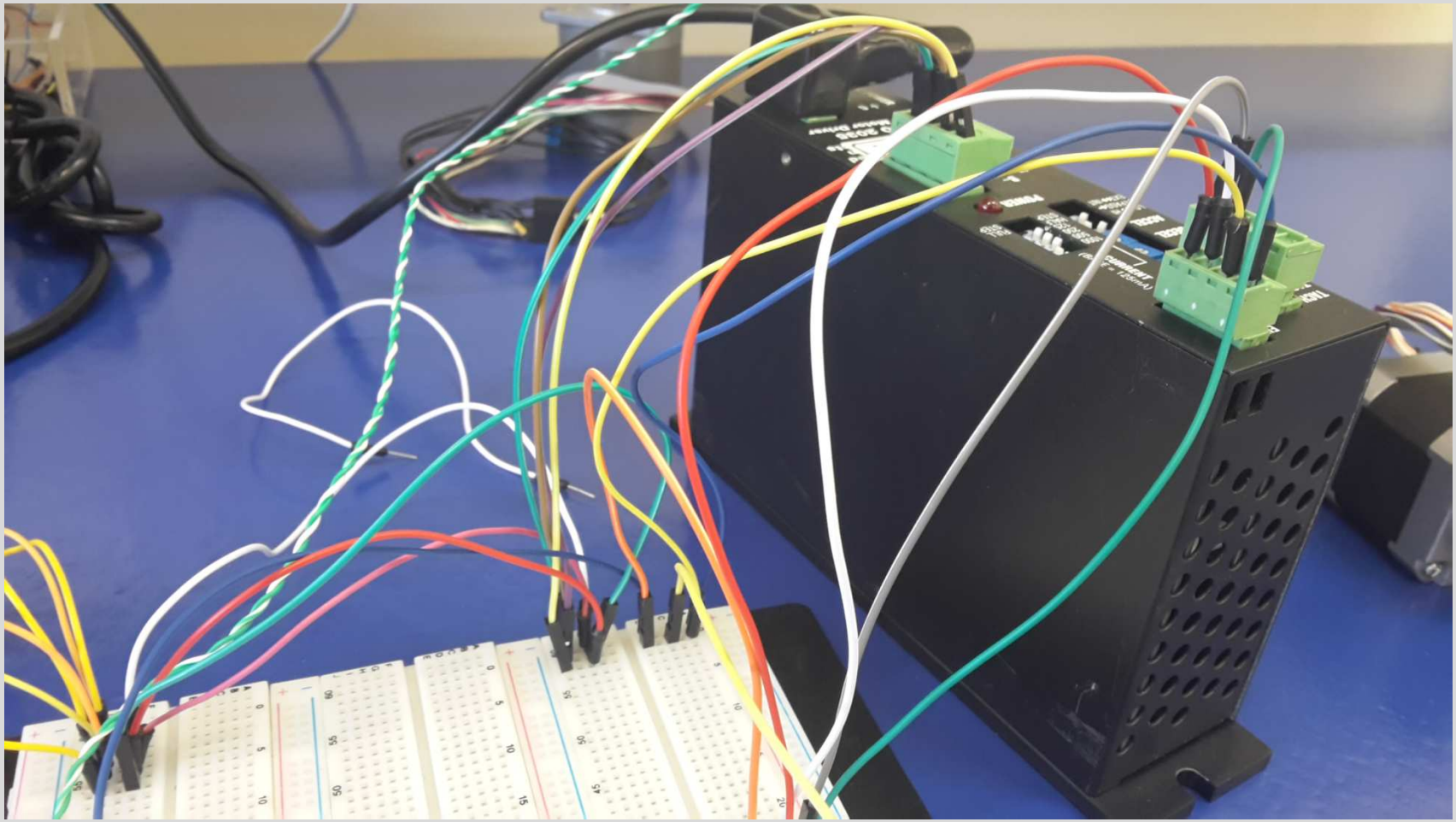
- **Lab Control** — research on aerial systems: control of quadcopter.



- **Lab Control** — research on aerial systems: experiments in a quadcopter.



- **Lab Control** — research on industrial systems: control of stepper motors in industrial applications.



- **Lab Control** — research on the theory of control systems: DC motor to support the experiments.

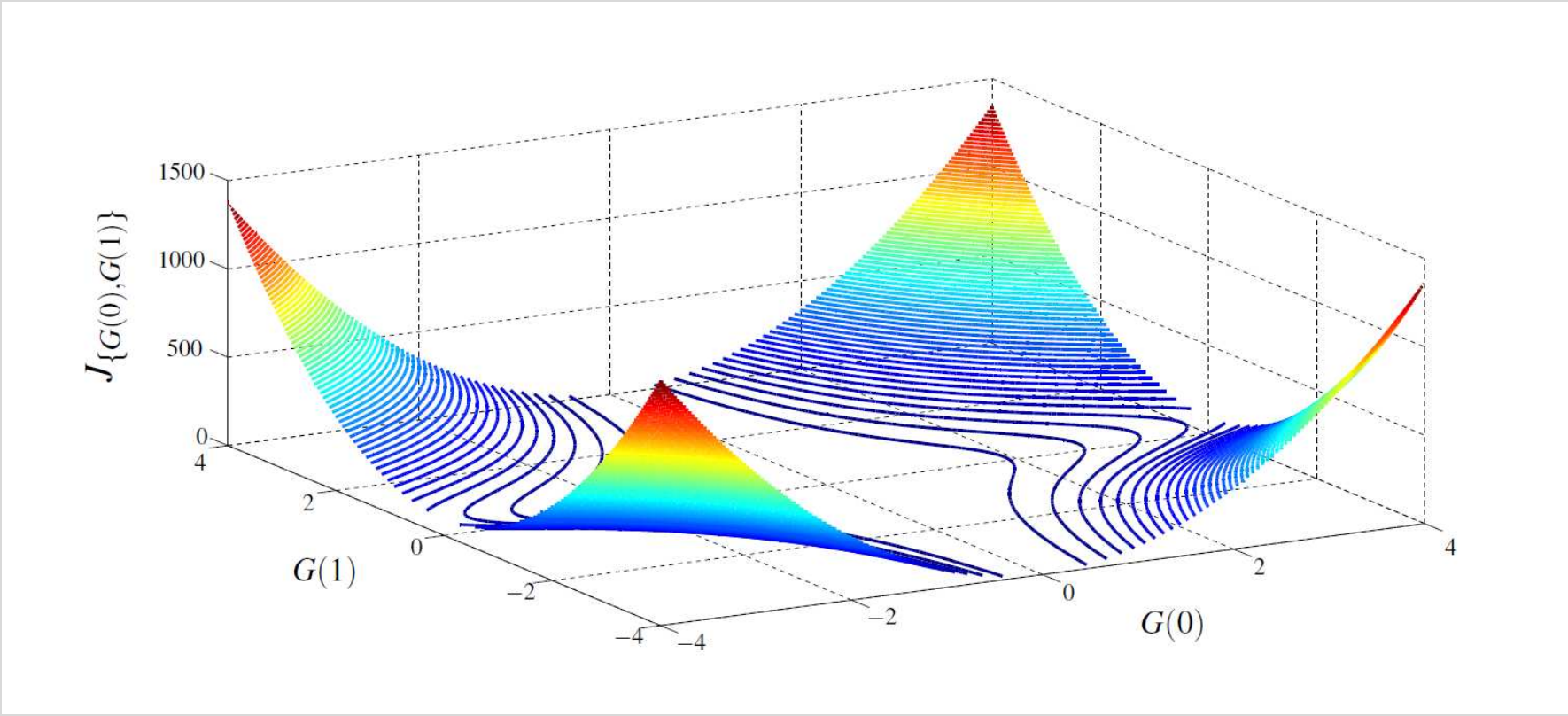
- **Lab Control** —research on autonomous vehicles.

- **Lab Control** — research on the theory of control systems: DC motor kit to support the theory through experiments.

- **Lab Control** — research on the theory of control systems: torsional apparatus.

- **Lab Control** — research on the theory of control systems: gyroscope used to support the theory through experiments.

- **Lab Control** — research on the numerics control systems.



- **Lab Control** — research on the theory of control systems.

$$L_{i,\mathbf{G}}(k) = Q_i + G(k)' R_i G(k) + \mathscr{L}^k_{i,\mathbf{G}}(L_{\mathbf{G}}(k+1)), \quad k = 0, \ldots, N-1, \ \forall i \in \mathscr{S},$$

with $L_{\mathbf{G}}(N) = F$.

After some algebraic manipulation (see Appendix for a detailed proof), we have

$$L_{\mathbf{G}}(k) - L_{\mathbf{K}}(k) = \delta^k_{\mathbf{G},\mathbf{K}} + \mathscr{L}^k_{\mathbf{K}}\big(L_{\mathbf{G}}(k+1) - L_{\mathbf{K}}(k+1)\big), \quad k = 0, \ldots, N-1, \quad (21)$$

with both $\mathbf{G}$ and $\mathbf{K}$ belonging to $\mathscr{G}$, where

$$\delta^k_{i,\mathbf{G},\mathbf{K}} := (G(k) - Z^k_i)' \Lambda^{k+1}_{i,\mathbf{G}} (G(k) - Z^k_i) - (K(k) - Z^k_i)' \Lambda^{k+1}_{i,\mathbf{G}} (K(k) - Z^k_i), \ \forall i \in \mathscr{S}, \quad (22)$$

with $\Lambda^k_{i,\mathbf{G}} := R_i + B_i' \mathscr{E}_i(L_{\mathbf{G}}(k)) B_i$ and $Z^k_i := -(\Lambda^{k+1}_{i,\mathbf{G}})^{-1} B_i' \mathscr{E}_i(L_{\mathbf{G}}(k+1)) A_i$. Moreover, if $\mathbf{G} = \mathbf{G}[\eta] \in \mathscr{G}$ is the gain sequence that satisfies (17) and $X(k) = X^{[\eta-1]}(k)$, $k = 0, \ldots, N$, is the corresponding second moment trajectory from *Step 2*, then we have [21, p. 1123]

$$\begin{aligned} \langle X(k), \delta^k_{\mathbf{G},\mathbf{K}} \rangle &= \|(\Lambda^{k+1}_{\mathbf{G}})^{\frac{1}{2}} (G(k) - Z^k) X(k)^{\frac{1}{2}}\|_2^2 - \|(\Lambda^{k+1}_{\mathbf{G}})^{\frac{1}{2}} (K(k) - Z^k) X(k)^{\frac{1}{2}}\|_2^2 \\ &= -\|(\Lambda^{k+1}_{\mathbf{G}})^{\frac{1}{2}} (G(k) - K(k)) X(k)^{\frac{1}{2}}\|_2^2 \end{aligned} \quad (23)$$

- **Lab Control** — the lab's door.

- **Lab Control** — the lab where research on automatic control systems takes place.

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